CSDL Informal Technical Note No. 6

RESTORATION OF CTD DATA FROM THE 1984-1985 DELAWARE RIVER AND BAY CIRCULATION SURVEY

Silver Spring, Maryland
July 2006

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
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Thomas Loeper

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ABSTRACT

The National Ocean Service (NOS) Delaware Bay Evaluation Environment is an evaluation of water circulation models. The evaluation uses common grids, offshore boundary conditions, bathymetry, shoreline data and historical observational data collected as part of the NOS Delaware River and Bay Circulation Survey conducted in 1984 and 1985. The historical data went through several system migrations and needed to be carefully reviewed before any simulation could occur. This report outlines the original Conductivity Temperature Depth (CTD) data acquisition procedures, condition of the original datasets and the methods used for recovering the historical data. This report also presents recommendations for recovering historical CTD data from other NOS circulation surveys.

1. INTRODUCTION

The purpose of this report is to present processed water conductivity and temperature readings with respect to depth (CTD) data collected from the 1984—1985 Delaware River and Bay (DR&B) Circulation Survey. The processed CTD data will be used in the development of the Delaware Bay Evaluation Environment Validation Dataset.

The DR&B Circulation Survey was conducted over two field seasons between March 1984 and May 1985 by the National Ocean Service (NOS). The survey area included the Delaware Bay, the Delaware River to its tidal limit in Trenton NJ, the Chesapeake and Delaware Canal (C&D Canal), and the inner continental shelf out to approximately 90 nautical miles from the mouth of the Delaware Bay. The Circulation Survey included measurements of water flow (currents), water level, temperature, salinity and other parameters needed for understanding the physical processes of the Delaware Estuary. The survey was conducted primarily for safe navigation of the waterway; however, data were also obtained to describe the circulation pattern of the estuary (Klavens, Stone and Stoney, 1986).

The results of the circulation study were used to update NOS products including the tide and tidal current tables as well as facilitate development of the Physical Oceanographic Real-Time System (PORTS) in the DR&B. These products have important applications in navigation, environmental management, emergency response and marine resource management.

In Chapter 2, we briefly describe the geographic setting and physical oceanography of the DR&B. Chapter 3 shows representative problems with the raw CTD profiles taken during the DR&B Circulation Survey and how the data were edited to resolve these problems. Ten of the casts were not useable so those profiles were deleted from the dataset. Chapter 4 discusses the sampling procedures, data processing and problems with the Grundy 9400 CTD Profiler. This chapter also has tabulated results for 239 casts performed with the Grundy instrument. Chapter 5 discusses the sampling procedures, data processing and inherent problems with the Applied Microsystems AML CTD-12 Portable CTD Profiler. This chapter also has tabulated results for 188 casts performed with the AML instrument. In Chapter 6, an overall assessment of the CTD information is presented followed by a plan for analyzing CTD casts from other estuaries collected over the past two decades.

2. DELAWARE ESTUARY PHYSICAL OCEANOGRAPHY

2.1 Geographic Setting

The Delaware River-Delaware Bay System is one of the major coastal plain estuaries of the eastern United States. The Delaware Estuary includes the entire water area from Capes May and Henlopen to Trenton. The Delaware Bay is the water area from Capes May and Henlopen to a line between the Stone Markers at Liston Point, DE and Hope Creek, NJ (Figure 2.1).

The Delaware Bay is divided into three regions: a shallow storage area on the New Jersey side, a center channel, and an area on the Delaware side characterized by alternating shoals and fingers of deep water. The Tidal River is the water area of the Delaware Estuary above the Delaware Bay. The Lower Estuary extends from the furthest extreme influence of oceanic salinity while the upstream limit is defined as the point where the chloride content of the water drops below 250 ppm. (Chloride is the ion found in greatest concentration in seawater.) Salinity concentration of 250 ppm is the commonly accepted maximum for potable water. This concentration is normally found in the region between Wilmington and Philadelphia. The Upper Estuary is that portion above the Lower Estuary (Polis and Kupferman, 1973).

Since the Delaware Estuary is a major US port, the main shipping channel is maintained by the US Army Corps of Engineers (USACE) to a project depth of approximately 12 meters (40 feet) from the mouth of the Bay to Philadelphia. The main channel from Philadelphia to Trenton is maintained at approximately 8 meters (25 feet). The USACE is planning to deepen the main shipping channel to approximately 13.7 meters (45 feet) from the mouth of the Bay to the Beckett Street Terminal in Camden, NJ (EPA, 2000).

2.2 Tides and Currents

The tide in the Delaware Estuary is dominated by the main lunar (semidiurnal) constituent having a period of 12.43 hours. The mean range of the tide at the Capes is 4.3 feet. The range generally increases through the estuary to about 6.7 feet at Trenton. The time of high water at Trenton is almost eight hours later than the time of high water at the Capes. The variation in tidal amplitude with distance along the estuary is due to the converging sides of the estuary which tends to increase the amplitude and friction which tends to reduce it (Parker, 1991). The actual tides may vary from those predicted from the harmonic constants mostly due to abnormal meteorological conditions.

The yearly Tide and Tidal Current tables produced by NOS predicted water tidal levels and currents but they cannot forecast the actual currents or water levels. Wind can have a significant effect on the water level of the estuary especially during extreme meteorological events. NOS has developed a PORTS installation for the DR&B which provides real-time currents, water levels, water and air temperature, salinity, wind speed and direction updated every six minutes. PORTS is a centralized data acquisition and dissemination system that provides oceanographic and meteorological data from numerous installations around the estuary. PORTS users can access the data in several formats including voice for phone users or information presented graphically on the internet.

DELAWARE RIVER & BAY

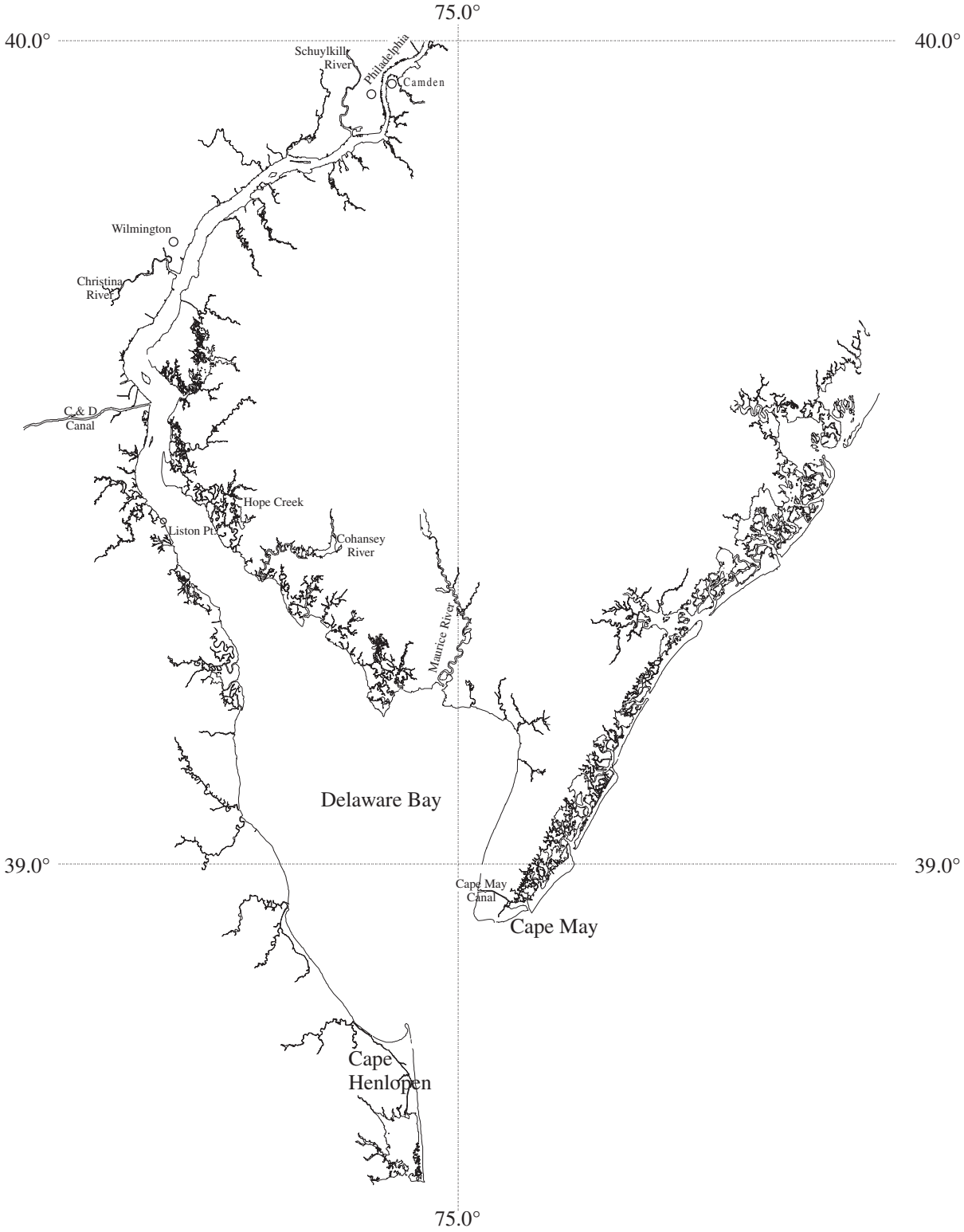

Figure 2.1 Geographic Setting from the Atlantic to Philadelphia, PA.

To better understand the physical oceanography of the DR&B, the text of Polis and Kupferman (1973) was reviewed. The next few paragraphs summarize the publication.

There are three generalizations that can be made about the effects of wind and atmospheric pressure on the water levels of the DR&B: strong meteorological effects are mostly confined to the winter months, meteorological low water levels occur when the wind is blowing from the northwest and the barometer has been low and is rising, and meteorological high water levels occur when there is an easterly wind and a falling barometer. Meteorological high water levels quite often accompany hurricanes. The arrival of the storm is heralded by a falling barometer and east winds. Water piles up somewhat to the right of the wind which is precisely the correct angle to flood the bay. It is difficult to predict the precise extent of the hurricane storm tide more than a few hours in advance — mostly because of the variations in storm tracks.

Surface currents tend to be directed along the axes of the bay except behind Cape May where the currents tend to follow the contours of the shore. The tidal currents have a speed of about 2.0 to 2.5 knots throughout the estuary at local maximum flood and local maximum ebb. The direct effect of river discharge on tidal flow is very small in the lower bay but observations of the bay have indicated a change to estuarine circulation pattern when the river flow changes the bay's salinity structure. Generally, as river discharge increases, a stronger two-layered "estuarine" circulation pattern is established due to the combined effects of fresh water overriding sea water. The circulation will be generally inland to the north and near the bottom, and seaward to the south and at the surface.

Salinity in the estuary varies from a value characteristic of coastal ocean water (30 to 33 ppt) to a value of about 0.1 ppt in the river. In the upper reaches of the tidal river, concentrations of the major species of dissolved ions are generally close to but somewhat smaller than world river averages. Generally, salinity values at any point in the estuary indicate the approximate degree of dilution of ocean water by river water, but correlating salinity in the bay with the river flow at Trenton on the day of observation has no causal significance. Long-term density data from NOS indicates there is an annual reversal in the transverse salinity gradient near the mouth of the bay. The explanation of this phenomenon is not known but it may involve wind mixing, seasonal variations in river discharge and possibly a reversal in the offshore surface current. Salinity along the navigation channel is due primarily to changes in the flow rate of the river. The river flow can be as much as 25 times larger or 10 times smaller than its long-term average value. The freshwater tends to override the more saline water, causing stratification. This is most clearly seen in the spring, the season when the river flow is at its peak. The phenomenon occurs because pure ocean water is about 2-½% more dense than fresh water and therefore tends to move along the bottom. The degree to which stratification occurs has been used as the basis of systems of estuary classification. These systems depend ultimately on the intensity of the mixing between river water and ocean water. In a stratified estuary, the ocean water will be capped by a thin layer of fresh water and the fresh water will move through the estuary from the river to the sea just fast enough to remove the discharge of the river. At the other extreme is the vertically mixed estuary which has the same salinity from top to bottom; the water has a net seaward flow at all levels. The factors which tend to induce mixing are the tidal motions, the roughness of the boundaries, wide shallow basins and the wind stresses on the surface. Opposing forces are high river flow and narrow, deep channels. The effect of increased river flow is

increased stratification of the water column. This means that while the surface salinity will decrease with increased river flow, bottom salinity will not decrease as rapidly and under some circumstances may actually increase. The historical data indicates that the bay actually changes estuarine type with variations in discharge, going form a vertical homogenous to a partially mixed configuration. In addition to the effect of river flow, salinity is effected to a lesser extent by monthly variations in tidal height and by changes in mean sea level. In the bay, the variations in salinity of coastal water moving down the New Jersey coast must also be considered.

In the lower estuary, temperature generally increases with depth in the winter and decreases with depth in the summer. Slight lateral variations also occur. Temperature has some slight effect on the density of water and therefore on the circulation pattern of the bay; however, the effect is generally negligible in comparison to salinity. More important is the effect of temperature on the biota, where it is often a controlling factor. In the upper estuary, temperature is controlled primarily by air temperature and solar radiation and is relatively constant along the estuary.

3. CTD CASTS

3.1 Significance of CTD Data in the DR&B

The CTD data provide information about the stratification of the estuary because it helps determine the influence of fresh water runoff on the estuarine circulation while also explaining water circulation driven by differences in density. The CTD data are used to define the vertical density structure in the estuary at a particular time and location.

CTD data, after conversion into salinity and density (sigma-T), provides information that can be used to interpret the density structure of the DR&B. Both the lateral and upstream/downstream gradients can serve as important factors in water movement in Delaware Bay. Temporal changes in the vertical density structure of DR&B, during a tidal cycle and seasonally, provide information concerning the contribution of runoff to the Bay's circulation.

3.2 The CTD Dataset

Two different instruments were used to collect CTD data; the Grundy 9400 CTD Profiler and the Applied Microsystems AML CTD-12 Portable CTD Profiler. Over 750 CTD casts were taken during the study. The entire unprocessed CTD dataset as well as the current and the meteorological datasets were archived by the National Oceanographic Data Center (NODC). The raw unprocessed data were archived over twenty years ago and a significant number of casts needed some editing to make them useful for the validation dataset.

Of the original 755 CTD casts taken during the DR&B Circulation Survey, 328 of the CTD casts had no time stamps associated with the records and had to be discarded. The remaining 427 casts were stored as seven independent data files originally copied from 9-track and 3-inch magnetic as raw data.

3.3 CTD Cast Procedures

According to the procedures established in the DR&B Circulation Study, CTD casts were taken twice at each current station, once at slack-before-flood and once at slack-before-ebb. During each surface-to-bottom cast, temperature, conductivity, and the associated depth (as a function of pressure) were recorded. A series of special CTD casts were taken along four transects during the spring and summer of the 1984 field season and every 15 days during the 1985 field season. The transects were repeated twice, once at slack-before-flood and once at slack-before-ebb. A supplemental CTD transect on the inner continental shelf adjacent to the Delaware Bay was also conducted.

Time series operations, at which CTD casts were taken every 30-minutes during a tidal cycle were conducted at three stations during the 1984 field season (Stations 2, 33 and 47 shown in Figures 4.1 and 4.2) and station 19 during the 1985 field season. The time series stations were repeated during the same intervals as the CTD transects, spring and summer during 1984 and every 15 days during the 1985 field season.

One special time series, a time series transect, consisted of CTD casts taken at each station along a transect at hourly intervals, during a complete tidal cycle. The transect (Station 3) was performed near the head of the Delaware Bay during the 1984 field season.

3.4 CTD Data Quality

To place the condition of the CTD casts in perspective, excerpts from the Center for Operational Oceanographic Products and Services (CO-OPS) Historical Circulation Survey Data (1973—1985): Inventory and Users Guide are summarized below.

Historical (including the DR&B Circulation Survey) data are defined as current survey data collected from the early 1970's through the 1980's. The historical data were often used to update the NOS Tidal Current Tables and NOS Tide Tables. Now the data are used to verify recent observations and for quality assurance studies.

The data were originally processed on UNIVAC 1100 in Suitland, MD, written to disk as unformatted files with an in-house adopted structure called Circulation Data Format, or CDF. In the late eighties, the data were read and subsequently written as an ASCII file to a 9-track tape and transported to the Hewlett Packard HP 9000/500 and stored as flat files. These files were then copied to tape. (Format: 9-track; 1600 b.p.i; ASCII; Non labeled; Record Length 80; Records per block 160; Total Block size 12,800 bytes)

Many manual steps were required to ultimately select the 9-track tape on which the data was recorded. To eliminate many of these steps and to provide an organized means in which one can search the data, the database of four tables was developed in 1994.

During the HP 9000 migration to an SGI ORIGIN 2000, the data were copied from 9-track tapes to CDs organized by project. Each CD contains several subdirectories corresponding to the subdirectories of the original 9-track tape. Under each subdirectory there are a number of files which match the number of logical files of the original 9-track tapes. These files are all in ASCII format which can be easily read. The start times for each of the files has been omitted or been assigned bogus values. This occurred during the system migration.

The accuracy and quality of historical CTD data need to be assessed for each historical survey. This report outlines the procedures needed to perform the assessment for the DR&B Circulation Survey.

4.0 GRUNDY 9400 CTD DATA

4.1 Instrumentation and Data Processing

The primary instrument used to collect CTD data during the DR&B Circulation study was the Grundy 9400 CTD Profiler. The conductivity, temperature, and water pressure (converted to depth during initial data processing) data collected by the Grundy 9400 were transmitted by cable back to the Grundy 8400 data logger aboard ship and were simultaneously recorded on a 9-track tape. The tape, along with a listing of the uncalibrated raw data outputted from the PDP11/34 shipboard computer, was sent to NOS for final processing.

The shipboard Circulation Measurements Data Processing system (CMDP) was not able to process Grundy data. However the Field Operations Officer routinely checked the performance of the Grundy CTD system by examining the raw data listings dumped to the PDP11/34.

Processing of the Grundy CTD data at NOS comprised four main stages: transferring the raw data tape to paper output using the PDP11/34 shipboard computer; assigning calibration constants to the temperature, conductivity, and pressure data; inserting header information for each data file; and final editing.

4.2 Data Quality Control and Analysis

The first step to assess accuracy and quality of the DR&B CTD casts was to plot the four files of Grundy CTD casts using the CSDL FORTRAN program del_ctd84.f This version of the program plots a profile of temperature, salinity, and sigma-t of each CTD cast of the 1984-85 DR&B Survey. The CSDL FORTRAN program gr_ctd.f was used to plot a chart of the sampling stations (Figure 4.1 through 4.3) . This program plots an image of the DR&B shoreline with all sampling stations located by longitude and latitude. Depths (in feet) were added near the stations to aid analysis.

A spreadsheet of the data on the Grundy files was created (Tables 4.1 through 4.4). The spreadsheet has columns for cast number, station number, latitude, longitude, date, time, plot depth, status of the cast, and a brief explanation about the cast. All the casts were examined and classified as good, bad or edit in the status column. Good casts needed no additional work while bad casts were not useable and were discarded from the final dataset. The casts marked edit needed some correction which included removing one or more outlying data points to smooth the profile, updating the station number, or adjusting the geographic point to correspond to the station number.

Much of the data collection for the DR&B Circulation Survey was conducted using the NOAA Ship FERREL (S492). Cruise logs from the FERREL for the 1985 field season (retrieved from http://noaa.imcwv.com/) provided clarification and verification for many of the Grundy casts. An auxiliary sampling system aboard the FERREL (Autosal Model 8400) was deployed at all the Grundy sampling stations verifying time, conductivity and temperature at one depth. The

cruise logs were also helpful when reconciling inconsistencies with time series and transect CTD casts.

The CTD casts were plotted and examined for consistency using a commercially available vector graphics program. One station was off by exactly one degree of latitude which was attributed to a transcription error. Another station was over 240 nautical miles west of the DR&B so it was discarded. Station depths were checked against charted depths but no inconsistencies were noted. Many of the continental shelf stations for the Grundy CTD files were incorrectly labeled. According to the DR&B Circulation Survey and survey logs, about half the stations had three digit labels but a portion of the Grundy files only had the last two of the three digits—the first digit was dropped in the files for some unknown reason. The CTD station files were checked against the survey logs and the spreadsheets and files were corrected.

The four raw Grundy CTD files named DECT01.original, DECT02.original, DECT06.original and DECT07.original were edited to remove extraneous data. Edited files were created from the originals and named DECT01.rework, DECT02.rework, DECT06.rework and DECT07.rework. Graphic examples of common problems with the raw data and edited files are presented in the Appendix in Figures A.1 through A.10. Modifications include removal of an near-surface, middle or near-bottom point in the cast, scattered data, and bad data which resulted in the cast being removed from the dataset.

DECT07 has six additional CTD stations (Figure 4.1 shows the location of Stations 34 through 39) that were not included as part of the original survey. A supplemental CTD transect on the inner shelf adjacent to Delaware Bay was run in conjunction with the Ocean Assessments Division (OAD) during the Northwest Monitoring Program Cruises (Klavens, Stone and Stoney, 1986).

GRUNDY 9400 CAST LOCATIONS

Figure 4.1 Grundy CTD Station Numbers (Red) and Depths in feet (Green) in the Delaware River.

GRUNDY 9400 CAST LOCATIONS

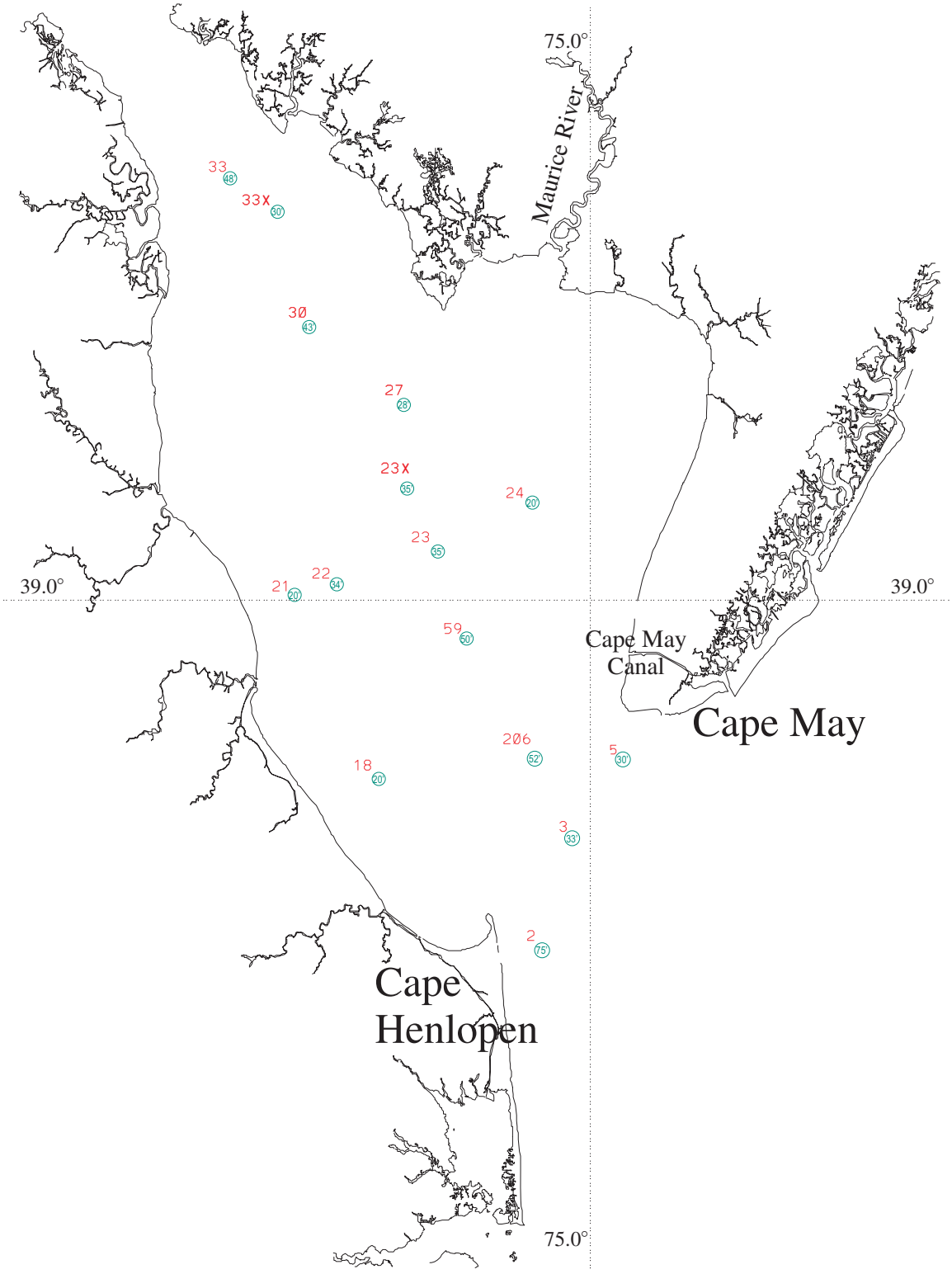

Figure 4.2 Grundy CTD Station Numbers (Red) and Depths in feet (Green) in the Delaware Bay.

GRUNDY 9400 CAST LOCATIONS

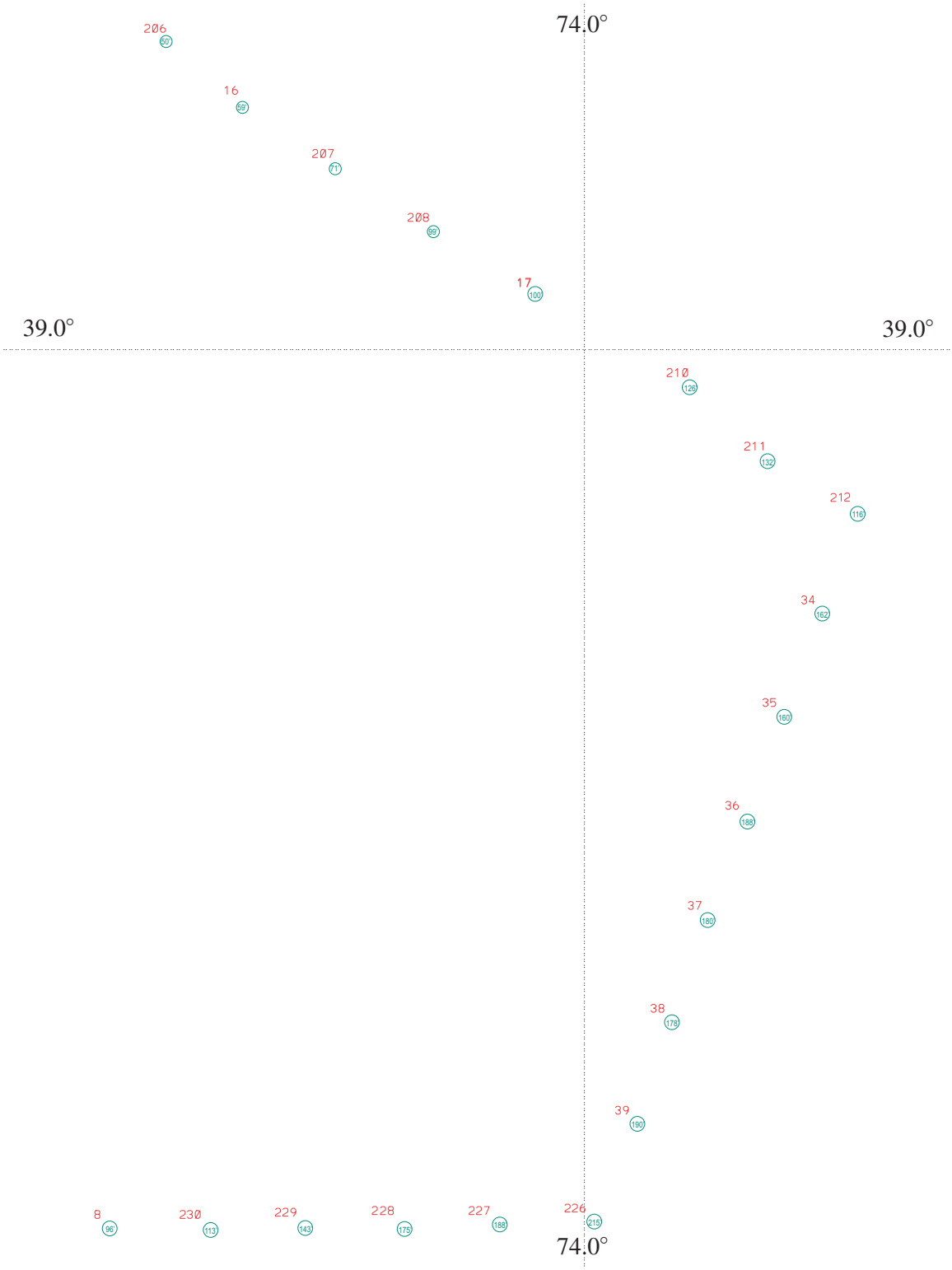

Figure 4.3 Grundy CTD Station Numbers (Red) and Depths in feet (Green) on the inner continental shelf near the mouth of the Delaware Bay.

Table 4.1 Tape 1 of 7, Delaware River and Bay CTD Profile Inventory Casts Taken with the Grundy 9400 CTD Profiler in 1984 Field Season.

Cast No.	Station No.	Lat (°N)	Long (°W)	Date	Time (UTC)	Plot Depth (m)	Status	Explanation
1	9	39.010	73.987	05/22/84	0920	39.0	Good	Sta. Number should be 209
2	17	39.051	74.072	05/22/84	1008	30.0	Good	
3	8	39.100	74.185	05/22/84	1443	34.0	Good	Sta. Number should be 208
4	7	39.150	74.298	05/22/84	1534	22.0	Good	Sta. Number should be 207
5	16	39.200	74.413	05/22/84	1627	19.0	Good	
6	6	39.242	74.507	05/22/84	1811	16.0	Good	Sta. Number should be 206
7	2	38.782	75.043	06/15/84	2235	19.0	Good	
8	12	38.885	73.700	06/16/84	0832	45.0	Good	Sta. Number should be 212
9	11	39.927	73.793	06/16/84	0920	41.0	Bad	Removed from dataset
10	10	38.968	73.887	06/16/84	1005	42.0	Bad	Removed from dataset
11	2	38.782	75.043	06/28/84	1750	18.0	Edit (Data Pt.)	First point removed
12	23	39.037	75.158	06/28/84	2135	11.0	Good	
13	33	39.268	75.347	06/28/84	2330	16.0	Good	
14	36	39.378	75.468	06/29/84	0028	12.0	Good	
15	39	39.470	75.565	06/29/84	0116	13.0	Edit (Data Pt.)	First point removed
16	51	39.880	75.173	06/29/84	1530	14.0	Good	
17	47	39.795	75.435	06/29/84	1812	14.0	Good	
18	45	39.722	75.530	06/29/84	1942	11.0	Good	
19	42	39.607	75.575	06/29/84	2109	12.0	Good	
20	41	39.577	75.575	06/29/84	2240	8.0	Good	
21	54	39.560	75.575	06/29/84	2258	11.0	Good	Sta. Number should be 154
22	55	39.552	75.537	06/30/84	1240	10.0	Good	Sta. Number should be 155
23	39	39.470	75.565	06/30/84	1430	14.0	Good	
24	36	39.378	75.468	06/30/84	1552	13.0	Good	
25	23	39.037	75.158	06/30/84	2035	12.0	Good	
26	2	38.782	75.043	07/13/84	1919	18.0	Edit (Data Pt.)	First point removed
27	23	39.037	75.158	07/13/84	2145	11.0	Edit (Data Pt.)	First point removed
28	60	39.570	75.553	07/14/84	1542	14.0	Good	Sta. Number should be 160
29	47	39.795	75.435	07/14/84	1833	15.0	Good	
30	45	39.722	75.530	07/14/84	2010	11.0	Good	
31	42	39.607	75.575	07/14/84	2130	12.0	Good	
32	34	39.290	75.313	07/15/84	1230	7.0	Good	Sta. Number should be 134
33	51	39.880	75.173	07/15/84	1348	12.0	Good	Sta. Number should be 151
34	60	39.570	75.553	07/15/84	1752	11.0	Good	Sta. Number should be 160
35	55	39.552	75.537	07/15/84	1735	11.0	Good	Sta. Number should be 155
36	12	38.885	73.700	07/17/84	0650	36.0	Good	Sta. Number should be 212
37	11	39.927	73.793	07/17/84	0745	41.0	Good	Sta. Number should be 211
38	9	39.010	73.978	07/17/84	0922	38.0	Good	Sta. Number should be 209
39	17	39.051	74.072	07/17/84	1018	33.0	Good	
40	8	39.100	74.185	07/17/84	1340	33.0	Good	Sta. Number should be 208

Table 4.1. (Continued) Tape 1 of 7, Delaware River and Bay CTD Profile Inventory Casts Taken with the Grundy 9400 CTD Profiler in 1984 Field Season.

Cast No.	Station No.	Lat (°N)	Long (°W)	Date	Time (UTC)	Plot Depth (m)	Status	Explanation
41	2	38.782	75.043	07/25/84	1515	18.0	Good	
42	2	38.782	75.043	07/25/84	1545	19.0	Edit (Data Pt.)	First point removed
43	2	38.782	75.043	07/25/84	1615	19.0	Edit (Data Pt.)	First point removed
44	2	38.782	75.043	07/25/84	1645	19.0	Edit (Data Pt.)	First point removed
45	2	38.782	75.043	07/25/84	1715	18.0	Edit (Data Pt.)	First point removed
46	2	38.782	75.043	07/25/84	1745	19.0	Good	
47	2	38.782	75.043	07/25/84	1815	19.0	Good	
48	2	38.782	75.043	07/25/84	1845	19.0	Good	
49	2	38.782	75.043	07/25/84	1915	19.0	Good	
50	2	38.782	74.043	07/25/84	1945	19.0	Edit (Posit)	Lat should be 75.043W
51	2	38.782	75.043	07/25/84	2015	19.0	Good	
52	2	38.782	75.043	07/25/84	2045	20.0	Good	
53	2	38.782	75.043	07/25/84	2215	20.0	Good	
54	2	38.782	75.043	07/25/84	2245	20.0	Good	
55	2	38.782	75.043	07/25/84	2315	20.0	Good	
56	2	38.782	75.043	07/25/84	2345	20.0	Good	
57	2	38.782	75.043	07/25/84	0015	21.0	Good	
58	2	38.782	75.043	07/25/84	0045	20.0	Edit (Data Pt.)	First point removed
59	2	38.782	75.043	07/25/84	0115	20.0	Edit (Data Pt.)	First point removed
60	2	38.782	75.043	07/25/84	0145	20.0	Edit (Data Pt.)	First point removed
61	2	38.782	75.043	07/25/84	0215	20.0	Edit (Data Pt.)	First point removed
62	2	38.782	75.043	07/25/84	0245	19.0	Edit (Data Pt.)	First point removed
63	2	38.782	75.043	07/25/84	0315	19.0	Edit (Data Pt.)	First point removed
64	2	38.782	75.043	07/25/84	0345	19.0	Edit (Data Pt.)	First point removed

Table 4.2 Tape 2 of 7, Delaware River and Bay CTD Profile Inventory Casts Taken with the Grundy 9400 CTD Profiler in 1984 Field Season.

Cast No.	Station No.	Lat (°N)	Long (°W)	Date	Time (UTC)	Plot Depth (m)	Status	Explanation
1	2	38.782	75.038	07/26/84	0415	39.0	Bad	Removed from dataset
2	47	39.802	75.413	07/26/84	1630	30.0	Good	
3	47	39.802	75.413	07/26/84	1700	34.0	Good	
4	47	39.802	75.413	07/26/84	1730	22.0	Good	
5	47	39.802	75.413	07/26/84	1800	19.0	Good	
6	47	39.802	75.413	07/26/84	1830	16.0	Good	
7	47	39.802	75.413	07/26/84	1900	19.0	Good	
8	47	39.802	75.413	07/26/84	1930	45.0	Good	
9	47	39.802	75.413	07/27/84	0000	41.0	Good	
10	47	39.802	75.413	07/27/84	0030	42.0	Good	
11	47	39.802	75.413	07/27/84	0100	18.0	Good	
12	47	39.802	75.413	07/27/84	0130	11.0	Good	
13	47	39.802	75.413	07/27/84	0200	16.0	Good	
14	47	39.802	75.413	07/27/84	0230	12.0	Good	
15	47	39.802	75.413	07/27/84	0300	13.0	Good	
16	47	39.802	75.413	07/27/84	0330	14.0	Good	
17	47	39.802	75.413	07/27/84	0400	14.0	Good	
18	47	39.802	75.413	07/27/84	0430	11.0	Good	
19	47	39.802	75.413	07/27/84	0500	12.0	Good	
20	47	39.802	75.413	07/27/84	0530	8.0	Good	
21	21	39.008	75.273	07/27/84	1219	11.0	Good	
22	22	39.018	75.251	07/27/84	1234	10.0	Good	Note: Data Scattered
23	23	39.038	75.158	07/27/84	1313	14.0	Good	Note: Data Scattered
24	25	39.038	75.988	07/27/84	1453	13.0	Good	
25	25	39.038	75.988	07/27/84	1700	12.0	Bad	Removed from dataset
26	24	39.067	75.070	07/27/84	1755	18.0	Good	
27	23	39.038	75.158	07/27/84	1840	11.0	Good	
28	22	39.018	75.251	07/27/84	1940	14.0	Edit (Data Pt.)	Last point removed
29	5	38.907	74.978	07/28/84	0000	15.0	Good	
30	33	39.262	75.347	08/01/84	1130	11.0	Edit (Data Pt.)	First point removed
31	33	39.262	75.347	08/01/84	1200	12.0	Good	
32	33	39.262	75.347	08/01/84	2100	7.0	Good	
33	33	39.262	75.347	08/02/84	0000	12.0	Good	
34	54	39.560	75.570	09/05/84	1208	11.0	Edit (Data Pt.)	First point removed
35	51	39.880	75.173	09/05/84	1715	11.0	Good	
36	33	39.262	75.347	09/05/84	2252	36.0	Good	
37	6	39.242	74.507	09/10/84	1543	41.0	Bad	Removed from dataset
38	16	39.223	74.412	09/10/84	1625	38.0	Good	
39	7	39.152	74.298	09/10/84	1754	33.0	Good	
40	17	39.052	74.072	09/10/84	1948	33.0	Good	Note: Data Scattered

Table 4.2. (Continued) Tape 2 of 7, Delaware River and Bay CTD Profile Inventory Casts Taken with the Grundy 9400 CTD Profiler in 1984 Field Season.

Cast No.	Station No.	Lat (°N)	Long (°W)	Date	Time (UTC)	Plot Depth (m)	Status	Explanation
41	18	38.897	75.213	09/18/84	1303	18.0	Good	
42	2	38.782	75.043	09/26/84	1540	19.0	Good	
43	23	39.040	79.092	09/26/84	1905	19.0	Edit (Posit)	Long should be 75.092
44	33	39.262	75.347	09/26/84	2145	19.0	Good	
45	51	39.880	75.173	09/28/84	1320	18.0	Good	
46	33	39.262	75.347	10/04/84	1355	19.0	Good	
47	23	39.038	75.158	10/04/84	1545	19.0	Good	
48	6	39.242	74.507	10/09/84	1535	19.0	Good	
49	16	39.223	74.412	10/09/84	1641	19.0	Good	
50	7	39.152	74.298	10/09/84	1732	19.0	Good	
51	8	39.102	74.185	10/09/84	1820	19.0	Good	
52	17	39.052	74.072	10/09/84	1910	20.0	Good	
53	9	39.010	73.987	10/09/84	2045	20.0	Good	
54	2	38.782	75.043	10/19/84	0130	20.0	Good	
55	2	38.782	75.043	10/19/84	1100	20.0	Good	
56	2	38.782	75.043	10/18/84	1400	20.0	Good	
57	16	39.223	74.412	10/20/84	0113	21.0	Edit (Data Pt.)	One point removed
58	47	39.802	75.413	10/22/84	2100	20.0	Good	
59	47	39.802	75.413	10/23/84	0300	20.0	Edit (Data Pt.)	First point removed
60	33	39.248	75.315	11/17/84	1835	20.0	Good	Sta. Number should be 33X

Table 4.3 Tape 6 of 7, Delaware River and Bay CTD Profile Inventory Casts Taken with the Grundy 9400 CTD Profiler in 1985 Field Season.

Cast No.	Station No.	Lat (°N)	Long (°W)	Date	Time (UTC)	Plot Depth (m)	Status	Explanation
1	59	38.975	75.115	04/04/85	0700	10.0	Good	
2	59	38.975	75.115	04/04/85	0730	10.0	Good	
3	59	38.975	75.115	04/04/85	0800	10.0	Good	
4	59	38.975	75.115	04/04/85	0830	10.0	Good	
5	59	38.975	75.115	04/04/85	0900	11.0	Good	
6	59	38.975	75.115	04/04/85	0930	11.0	Good	
7	59	38.975	75.115	04/04/85	1000	12.0	Good	
8	59	38.975	75.115	04/04/85	1030	12.0	Good	
9	59	38.975	75.115	04/04/85	1100	12.0	Good	
10	59	38.975	75.115	04/04/85	1130	12.0	Good	
11	59	38.975	75.115	04/04/85	1200	12.0	Good	
12	59	38.975	75.115	04/04/85	1230	12.0	Good	
13	59	38.975	75.115	04/04/85	1300	12.0	Good	
14	59	38.975	75.115	04/04/85	1330	11.0	Good	
15	59	38.975	75.115	04/04/85	1400	11.0	Good	
16	59	38.975	75.115	04/04/85	1430	11.0	Good	
17	59	38.975	75.115	04/04/85	1500	11.0	Edit (Data Pt.)	First point removed
18	59	38.975	75.115	04/04/85	1530	10.0	Good	
19	59	38.975	75.115	04/04/85	1600	10.0	Good	
20	27	39.120	75.218	04/16/85	1931	9.0	Good	
21	30	39.178	75.273	04/16/85	2006	13.0	Good	
22	33	39.248	75.317	04/16/85	2047	8.0	Good	Sta. Number should be 33X
23	1	39.268	75.348	04/16/85	2114	15.0	Good	Sta. Number should be 201
24	1	39.268	75.348	04/17/85	1800	15.0	Good	Sta. Number should be 201
25	33	39.248	75.317	04/17/85	1817	16.0	Good	Sta. Number should be 33X
26	30	39.178	75.273	04/17/85	1850	14.0	Good	
27	27	39.120	75.218	04/17/85	1921	13.0	Good	
28	23	39.082	75.187	04/17/85	1945	13.0	Good	Sta. Number should be 23X
29	59	38.975	75.115	04/17/85	2036	15.0	Edit (Data Pt.)	First point removed
30	206	38.913	75.068	04/17/85	2119	16.0	Good	
31	3	38.858	75.025	04/17/85	2157	12.0	Good	
32	59	38.975	75.115	04/17/85	2300	11.0	Good	
33	59	38.975	75.115	04/17/85	2300	12.0	Good	
34	59	38.975	75.115	04/18/85	0000	11.0	Good	
35	59	38.975	75.115	04/18/85	0030	11.0	Good	
36	59	38.975	75.115	04/18/85	0100	11.0	Good	
37	59	38.975	75.115	04/18/85	0130	11.0	Good	
38	59	38.975	75.115	04/18/85	0200	11.0	Good	
39	59	38.975	75.115	04/18/85	0230	11.0	Good	
40	59	38.975	75.115	04/18/85	0300	11.0	Good	

Table 4.3. (Continued) Tape 6 of 7, Delaware River and Bay CTD Profile Inventory Casts Taken with the Grundy 9400 CTD Profiler in 1985 Field Season.

Cast No.	Station No.	Lat (°N)	Long (°W)	Date	Time (UTC)	Plot Depth (m)	Status	Explanation
41	59	38.975	75.115	04/18/85	0330	11.0	Good	
42	59	38.975	75.115	04/18/85	0400	11.0	Good	
43	59	38.975	75.115	04/18/85	0430	10.0	Good	
44	59	38.975	75.115	04/18/85	0500	10.0	Good	
45	59	38.975	75.115	04/18/85	0530	10.0	Good	
46	59	38.975	75.115	04/18/85	0600	10.0	Good	
47	59	38.975	75.115	04/18/85	0630	10.0	Good	
48	59	38.975	75.115	04/18/85	0700	10.0	Good	
49	59	38.975	75.115	04/18/85	0730	10.0	Good	
50	59	38.975	75.115	04/18/85	0800	10.0	Good	
51	59	38.975	75.115	04/18/85	0830	10.0	Good	
52	59	38.975	75.115	04/18/85	0900	10.0	Good	
53	59	38.975	75.115	04/18/85	0930	10.0	Good	
54	59	38.975	75.115	04/18/85	1000	11.0	Good	
55	59	38.975	75.115	04/18/85	1030	11.0	Good	
56	59	38.975	75.115	04/18/85	1100	11.0	Edit (Data Pt.)	First point removed
57	59	38.975	75.115	04/18/85	1300	11.0	Good	
58	59	38.975	75.115	04/18/85	1200	11.0	Good	
59	3	38.858	75.025	04/29/85	1412	11.0	Good	
60	206	38.913	75.068	04/29/85	1456	12.0	Good	

Table 4.4 Tape 7 of 7, Delaware River and Bay CTD Profile Inventory Casts Taken with the Grundy 9400 CTD Profiler in 1985 Field Season.

Cast No.	Station No.	Lat (°N)	Long (°W)	Date	Time (UTC)	Plot Depth (m)	Status	Explanation
1	59	39.982	75.112	04/29/85	1541	15.0	Good	
2	23	39.082	75.187	04/29/85	1634	14.0	Good	Sta. Number should be 23X
3	27	39.120	75.218	04/29/85	1704	13.0	Good	
4	30	39.178	75.273	04/29/85	1745	12.0	Good	
5	33	39.248	75.317	04/29/85	1830	16.0	Good	Sta. Number should be 33X
6	1	39.268	75.348	04/29/85	1855	16.0	Good	Sta. Number should be 201
7	1	39.268	75.348	04/29/85	2100	16.0	Good	Sta. Number should be 201
8	33	39.248	75.317	04/29/85	2121	15.0	Good	Sta. Number should be 33X
9	30	39.178	75.273	04/29/85	2202	15.0	Good	
10	27	39.120	75.218	04/29/85	2237	14.0	Good	
11	23	39.082	75.187	04/29/85	2259	13.0	Good	Sta. Number should be 23X
12	59	38.973	75.112	04/29/85	2353	16.0	Good	
13	6	38.913	75.068	04/30/85	0040	16.0	Good	Sta. Number should be 206
14	3	38.858	75.025	04/30/85	0115	11.0	Good	
15	8	38.325	74.567	04/30/85	0551	36.0	Good	
16	30	38.325	74.455	04/30/85	0637	35.0	Good	Sta. Number should be 230
17	29	38.327	74.343	04/30/85	0722	44.0	Good	Sta. Number should be 229
18	28	38.328	74.230	04/30/85	0810	54.0	Good	Sta. Number should be 228
19	27	38.328	74.118	04/30/85	0900	58.0	Good	Sta. Number should be 227
20	26	38.330	74.007	04/30/85	0946	66.0	Good	Sta. Number should be 226
21	39	38.407	73.957	04/30/85	1100	59.0	Good	Sta. Number should be 239
22	38	38.487	73.915	04/30/85	1154	55.0	Good	Sta. Number should be 238
23	37	38.567	73.872	04/30/85	1237	56.0	Good	Sta. Number should be 237
24	36	38.645	73.828	04/30/85	1322	53.0	Good	Sta. Number should be 236
25	35	38.725	73.785	04/30/85	1410	49.0	Good	Sta. Number should be 235
26	34	38.805	73.740	04/30/85	1453	50.0	Good	Sta. Number should be 234
27	12	38.885	73.700	04/30/85	1538	45.0	Good	Sta. Number should be 212
28	10	38.968	73.887	04/30/85	1720	29.0	Good	Sta. Number should be 210
29	17	39.052	74.072	04/30/85	1915	19.0	Good	
30	59	38.973	75.112	05/01/85	1930	10.0	Good	
31	59	38.973	75.112	05/01/85	2000	10.0	Good	
32	59	38.973	75.112	05/01/85	2030	10.0	Good	
33	59	38.973	75.112	05/01/85	2100	11.0	Good	
34	59	38.973	75.112	05/01/85	2130	11.0	Good	
35	59	38.973	75.112	05/01/85	2200	11.0	Good	
36	59	38.973	75.112	05/01/85	2230	11.0	Good	
37	59	38.973	75.112	05/01/85	2300	11.0	Good	
38	59	38.973	75.112	05/01/85	2330	11.0	Good	
39	59	38.973	75.112	05/02/85	0000	11.0	Good	
40	59	38.973	75.112	05/02/85	0030	11.0	Good	

Table 4.4. (Continued) Tape 7 of 7, Delaware River and Bay CTD Profile Inventory Casts Taken with the Grundy 9400 CTD Profiler in 1985 Field Season.

Cast No.	Station No.	Lat (°N)	Long (°W)	Date	Time (UTC)	Plot Depth (m)	Status	Explanation
41	59	38.973	75.112	05/02/85	0100	11.0	Good	
42	59	38.973	75.112	05/02/85	0130	11.0	Good	
43	59	38.973	75.112	05/02/85	0200	11.0	Good	
44	59	38.973	75.112	05/02/85	0230	10.0	Good	
45	59	38.973	75.112	05/02/85	0300	10.0	Good	
46	59	38.973	75.112	05/02/85	0330	11.0	Good	
47	59	38.973	75.112	05/02/85	0400	11.0	Good	
48	59	38.973	75.112	05/02/85	0430	11.0	Good	
49	59	38.973	75.112	05/02/85	0500	11.0	Good	
50	59	38.973	75.112	05/02/85	0530	11.0	Good	
51	59	38.973	75.112	05/02/85	0600	11.0	Good	
52	59	38.973	75.112	05/02/85	0630	11.0	Good	
53	59	38.973	75.112	05/02/85	0700	11.0	Good	
54	59	38.973	75.112	05/02/85	0730	11.0	Good	
55	59	38.973	75.112	05/02/85	0800	11.0	Good	

5.0 AML CTD-12 CTD DATA

5.1 Instrumentation and Data Processing

The second CTD measuring system used during the DR&B Circulation Survey was the AML Portable CTD Profiler. The following data acquisition and processing procedures were taken from the DR&B Circulation Survey Report. The data processing procedures for the AML CTD meter were more labor intensive than for the Grundy 9400. Data processing was a function shared by both the ship's crew and NOS employees in Rockville, Maryland.

CTD data processing started when the device was deployed. In the deployment log the Field Operations Officer recorded the exact time the device entered the water. Similarly, on recovery, the time the device left the water was recorded in the recovery log. For the CTD data to be acceptable, the elapsed time (between deployment and recovery) must be equal to the number of time intervals counted internally by the meter (i.e. the data "time checks").

The Circulation Measurements Data Processing System (CMDP) aspect of shipboard data processing allowed the ship's Field Operations Officer to scrutinize the quality of data recorded by the device and to check whether the elapsed time of device operation matched the time increments recorded. Each 3-inch tape was translated onto a 5-inch tape using a Grundy or CAMAC translator. The tape was then read by the PDP 11/34 using the CMDP shipboard processing system. If the CMDP system determined that the CTD data "time-checked", the CMDP software then applied actual times to each of the time increments on the 9-track output tape.

When the 9-track CMDP tape was received by NOS, the second stage of data processing started. The tape was copied onto a permanent disc file; separate files were created with the uncalibrated meter data and calibration constants. The files were examined to ensure that calibration constants matched those supplied by the calibration engineers. Time checking of each file was also reviewed to corroborate the field checks. If missing or extra data points were indicated, an attempt was made to determine if they could be located on the data file and corrected.

The final phase of data processing included the correcting, if necessary, of missing or extra data points, eliminating data points recorded by the CTD meters before entering the water or after the device was retrieved, and applying actual times to each data point.

5.2 Data Quality Control and Analysis

The first step to assess accuracy and quality of the DR&B CTD casts for the AML instrument was to plot all the files from all three of the tapes using the CSDL FORTRAN program del_ctd84.f This version of the program plots a profile of temperature, salinity, and sigma-t of each CTD cast of the 1984-85 DR&B Survey. The CSDL FORTRAN program gr_ctd.f was used to plot a chart of the sampling stations (Figure 5.1 through 5.3) . This program plots an image of the DR&B shoreline with all sampling stations located by longitude and latitude. Depths (in feet) were added near the stations to aid analysis.

A spreadsheet of the data on the three AML files was created (Tables 5.1 through 5.3). The

spreadsheet has columns for cast number, station number, latitude, longitude, date, time, plot depth, status of the cast, and a brief explanation about the cast. All the casts were examined and classified as good, bad or edit in the status column. Good casts needed no additional work while bad casts were not useable and were discarded from the final dataset. The casts marked edit needed some correction which included removing one or more data points to smooth the profile, updating the station number, adjusting the depth to correspond to the actual charted water depth, or adjusting the geographic point to correspond to the station number.

Cruise logs from the 1985 field season did not provide any clarification for the AML dataset. The AML Profiler was a portable device that was deployed on small craft which had no backup system to reconcile data. Many of the CTD casts were made at current monitoring stations during the circulation survey so data collected by the current stations during the survey were used to cross check surface temperature readings of the AML CTD meters.

The CTD casts were plotted and examined for consistency using a commercially available vector graphics program. Station depths were checked against charted depths and four stations were adjusted to incorporate more data that were collected in the water column. None of the AML CTD files had stations that were incorrectly labeled. On three occasions exact duplicates of a cast were repeated on the following cast. The second of each these casts was discarded.

The three raw AML CTD files named DECT03.original, DECT04.original & DECT05.original were edited to remove extraneous data. Edited files were created from the originals and named DECT03.rework, DECT04.rework and DECT05.rework. Graphic examples of common problems with the raw data and edited files are presented in Appendix A in Figures A.1 through A.10. Modifications include removal of an initial, middle or final point in the cast, adjusting the depth to incorporate more of the data that was originally collected, scattered data, and bad data which resulted in the cast being removed from the dataset. The raw AML CTD files had excess data that was included below the cast cutoff depth that was probably added during the multiple system migrations of the past 20 years. Any information that was present below the cutoff depth was deleted in the three rework files.

AML CTD-12 CAST LOCATIONS

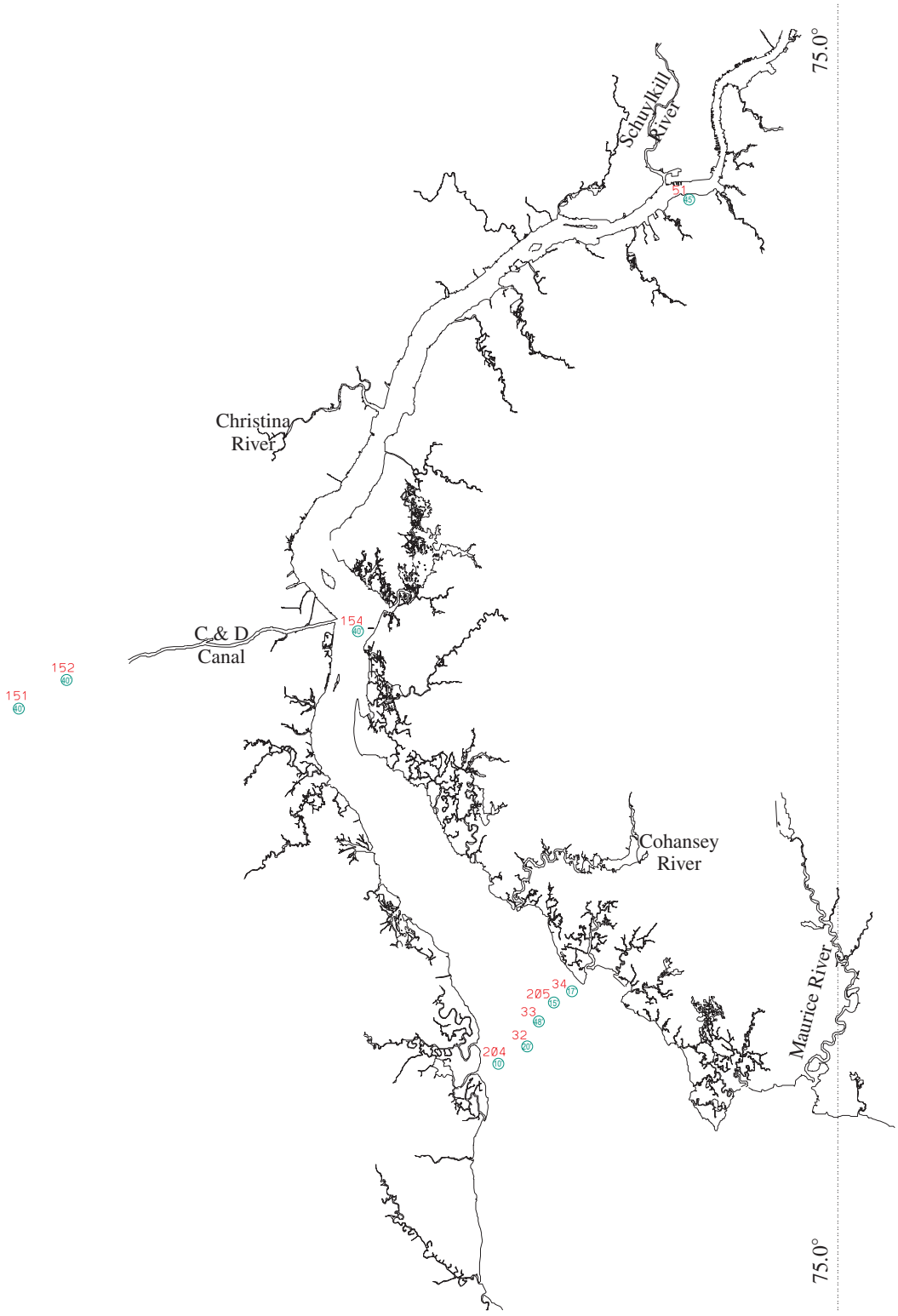

Figure 5.1 AML CTD Station Numbers (Red) and Depths in feet (Green) in the Delaware River.

AML CTD-12 CAST LOCATIONS

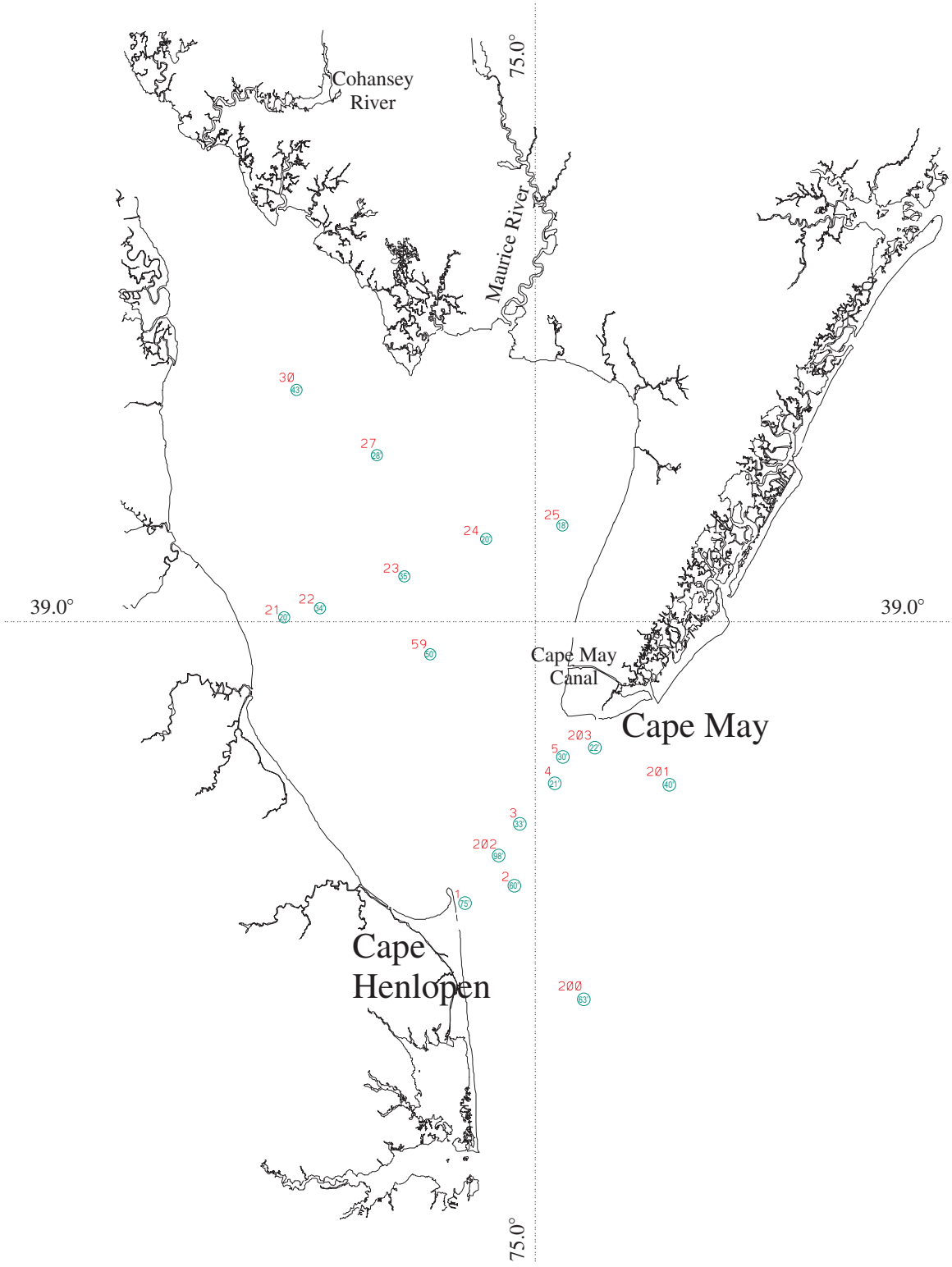

Figure 5.2 AML CTD Station Numbers (Red) and Depths in feet (Green) in the Delaware Bay.

AML CTD-12 CAST LOCATIONS

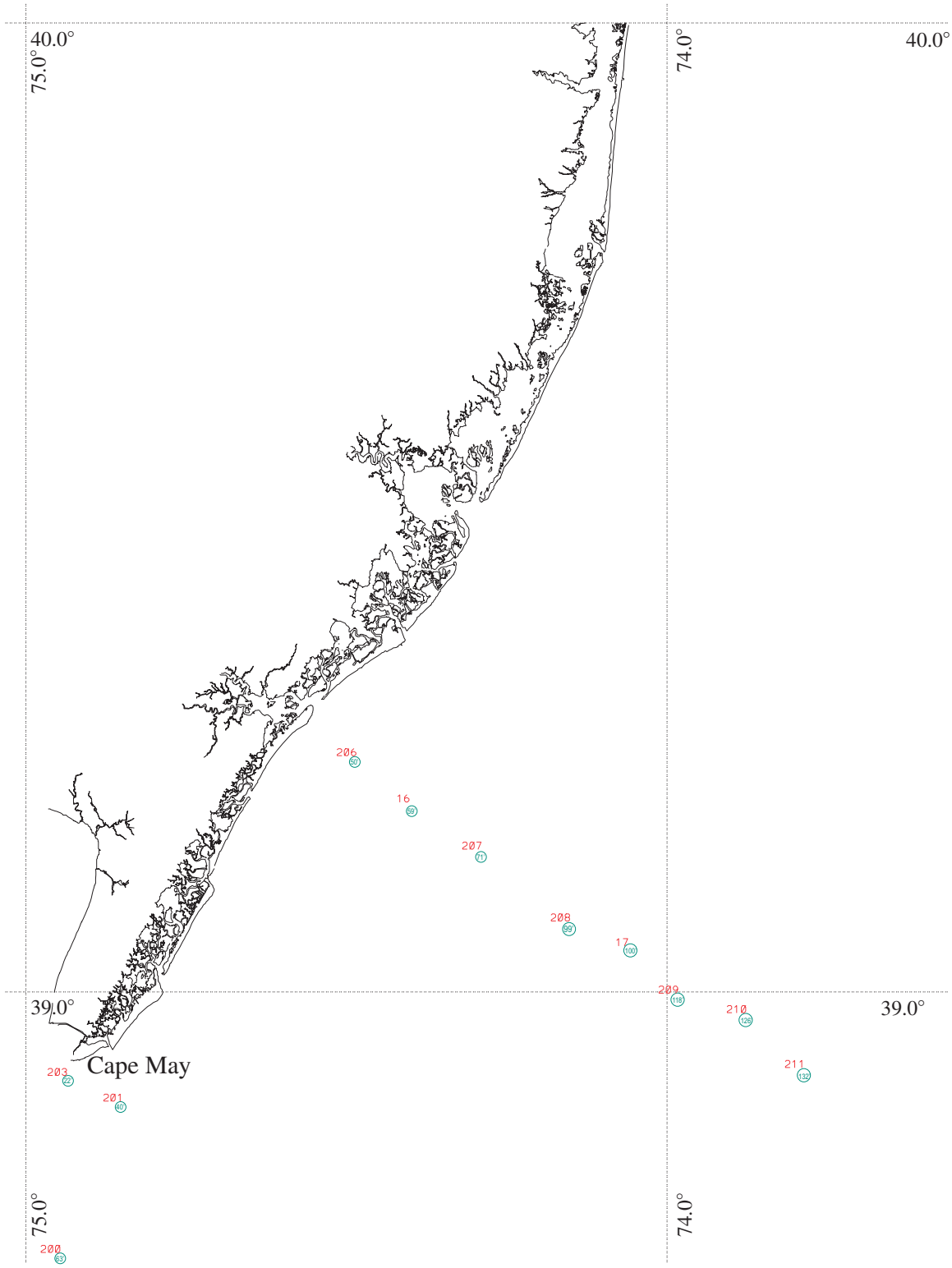

Figure 5.3 AML CTD Station Numbers (Red) and Depths in feet (Green) on the inner continental shelf near the mouth of the Delaware Bay.

Table 5.1 Tape 3 of 7, Delaware River and Bay CTD Profile Inventory
Casts Taken with the AML CTD-12 Portable CTD Profiler in 1985 Field Season.

Cast No.	Station No.	Lat (°N)	Long (°W)	Date	Time (UTC)	Plot Depth (m)	Status	Explanation
1	154	39.561	75.570	03/16/85	1800	11.0	Good	
2	33	39.269	75.348	03/16/85	2213	12.0	Good	
3	23	39.039	75.158	03/17/85	1409	11.0	Edit (Data Pt.)	Last point removed
4	154	39.561	75.570	03/28/85	1803	12.0	Good	
5	23	39.039	75.158	03/28/85	2350	11.0	Edit (Data Pt.)	Last point removed
6	23	39.039	75.158	04/05/85	1549	11.0	Good	
7	154	39.561	75.570	04/05/85	2050	11.0	Good	
8	51	39.880	75.173	04/07/85	1455	13.0	Edit (Data Pt.)	Last point removed
9	17	39.051	39.051	04/08/85	1338	30.0	Good	
10	16	39.201	74.413	04/08/85	1656	18.0	Good	
11	25	39.078	74.981	04/21/85	1902	5.0	Good	
12	24	39.067	75.070	04/21/85	1923	6.0	Good	
13	23	39.039	75.158	04/21/85	1943	11.0	Bad	Removed from dataset
14	24	39.067	75.070	04/22/85	1434	5.0	Good	
15	23	39.039	75.158	04/21/85	1513	11.0	Good	
16	22	39.016	75.251	04/21/85	1538	10.0	Edit (Data Pt.)	Last point removed
17	21	39.008	75.284	04/21/85	1559	6.0	Good	
18	202	38.836	75.056	04/22/85	1831	30.0	Good	
19	3	38.859	75.024	04/22/85	1854	9.0	Good	
20	4	38.890	74.986	04/21/85	1907	6.0	Good	
21	5	38.906	74.978	04/21/85	1921	9.0	Good	
22	203	39.916	74.951	04/21/85	1921	6.0	Good	
23	203	39.916	74.951	04/23/85	1408	6.0	Good	
24	5	38.906	74.978	04/23/85	1427	9.0	Good	
25	4	38.890	74.986	04/23/85	1443	6.0	Good	
26	3	38.859	75.024	04/23/85	1503	10.0	Good	
27	202	38.836	75.056	04/23/85	1512	30.0	Good	
28	1	38.799	75.082	04/23/85	1534	22.0	Good	
29	33	39.269	75.348	04/23/85	1957	14.0	Good	
30	154	39.561	75.570	04/26/85	2246	11.0	Edit (Data Pt.)	Last point removed
31	23	39.039	75.158	05/05/85	1718	11.0	Good	
32	33	39.269	75.348	05/05/85	1934	14.0	Good	
33	51	39.880	75.173	05/09/85	2020	13.0	Good	
34	5	38.906	74.978	05/10/85	1352	9.0	Edit (Data Pt.)	Last point removed
35	24	39.067	75.070	05/10/85	1546	3.0	Good	
36	23	39.039	75.158	05/10/85	1625	11.0	Edit (Data Pt.)	Last point removed
37	22	39.016	75.251	05/10/85	1716	10.0	Good	
38	23	39.039	75.158	05/10/85	1756	11.0	Good	
39	2	38.813	75.024	05/11/85	1246	17.0	Good	
40	5	38.906	74.978	05/16/85	1352	9.0	Good	

Table 5.1 Tape 3 of 7, Delaware River and Bay CTD Profile Inventory (Cont.)
Casts Taken with the AML CTD-12 Portable CTD Profiler in 1985 Field Season.

Cast No.	Station No.	Lat (°N)	Long (°W)	Date	Time (UTC)	Plot Depth (m)	Status	Explanation
41	23	39.039	75.158	05/16/85	1445	11.0	Good	
42	3	39.269	75.348	05/16/85	1814	15.0	Good	
43	2	38.813	75.038	05/17/85	1931	17.0	Good	
44	23	39.039	75.158	07/28/85	1325	11.0	Edit (Data Pt.)	First pt. & last 2 pts. removed
45	24	39.067	75.070	07/28/85	1405	5.0	Good	
46	25	39.078	74.981	07/28/85	1446	5.0	Edit (Data Pt.)	First point removed
47	203	38.916	74.951	07/28/85	1710	7.0	Edit (Data Pt.)	First point removed
48	5	38.906	74.978	07/28/85	1727	8.0	Edit (Data Pt.)	First point removed
49	4	38.890	74.986	07/28/85	1742	5.0	Edit (Data Pt.)	First point removed
50	3	38.859	75.024	07/28/85	1603	9.0	Good	
51	202	38.836	75.056	07/28/85	1822	22.0	Edit (Data Pt.)	First point removed
52	1	38.799	75.082	07/28/85	1835	22.0	Edit (Data Pt.)	First point removed
53	208	39.077	74.167	07/29/85	1402	30.0	Edit (Data Pt.)	First point removed
54	207	39.152	74.304	07/29/85	1548	22.0	Good	
55	16	39.201	74.413	07/29/85	1548	17.0	Edit (Data Pt.)	First point removed
56	206	39.248	74.500	07/28/85	1648	14.0	Edit (Data Pt.)	Last point removed
57	205	39.283	75.337	08/02/85	1144	4.0	Good	
58	32	39.251	75.358	08/02/85	1159	5.0	Good	
59	204	39.239	75.386	08/02/85	1208	3.0	Good	
60	34	39.290	75.313	08/02/85	1231	5.0	Good	
61	205	39.283	75.337	08/02/85	1231	4.0	Good	
62	32	39.251	75.358	08/02/85	1300	5.0	Good	
63	204	39.239	75.386	08/02/85	1311	3.0	Good	
64	34	39.290	75.313	08/02/85	1331	5.0	Good	

Table 5.2 Tape 4 of 7, Delaware River and Bay CTD Profile Inventory
Casts Taken with the AML CTD-12 Portable CTD Profiler in 1985 Field Season

Cast No.	Station No.	Lat (°N)	Long (°W)	Date	Time (UTC)	Plot Depth (m)	Status	Explanation
1	205	39.283	75.337	08/02/85	1344	4.0	Good	
2	32	39.251	75.358	08/02/85	1359	5.0	Good	
3	204	39.239	75.386	08/02/85	1408	3.0	Good	
4	34	39.290	75.313	08/02/85	1431	5.0	Good	
5	205	39.283	75.337	08/02/85	1444	4.0	Good	
6	32	39.251	75.358	08/02/85	1508	5.0	Good	
7	205	39.283	75.337	08/02/85	1544	4.0	Good	
8	32	39.251	75.358	08/02/85	1559	5.0	Good	
9	204	39.239	75.386	08/02/85	1608	3.0	Good	
10	34	39.290	75.313	08/02/85	1631	5.0	Good	
11	205	39.283	75.337	08/02/85	1644	4.0	Good	
12	32	39.251	75.358	08/02/85	1659	5.0	Good	
13	204	39.239	75.386	08/02/85	1708	1.0	Bad	Removed from dataset
14	34	39.290	75.313	08/02/85	1731	5.0	Good	
15	205	39.283	75.337	08/02/85	1744	4.0	Good	
16	32	39.251	75.358	08/02/85	1759	5.0	Good	
17	204	39.239	75.386	08/02/85	1806	1.0	Bad	Removed from dataset
18	34	39.290	75.313	08/02/85	1831	5.0	Good	
19	205	39.283	75.337	08/02/85	1844	4.0	Good	
20	32	39.251	75.358	08/02/85	1859	5.0	Good	
21	204	39.239	75.386	08/02/85	1908	3.0	Good	
22	34	39.290	75.313	08/02/85	1931	5.0	Good	
23	205	39.283	75.337	08/02/85	1944	3.0	Good	
24	32	39.251	75.358	08/02/85	1959	4.0	Good	
25	204	39.239	75.386	08/02/85	2008	5.0	Good	
26	34	39.290	75.313	08/02/85	2031	5.0	Good	
27	2	39.283	75.337	08/02/85	2044	4.0	Edit (Station No.)	Sta. Number should be 205
28	32	39.251	75.358	08/02/85	2059	5.0	Good	
29	204	39.239	75.386	08/02/85	2110	3.0	Good	
30	34	39.290	75.313	08/02/85	2132	5.0	Good	
31	205	39.283	75.337	08/02/85	2144	4.0	Good	
32	32	39.251	75.358	08/02/85	2159	5.0	Good	
33	204	39.239	75.386	08/02/85	2208	3.0	Good	
34	32	39.251	75.358	08/02/85	2231	5.0	Good	
35	205	39.283	75.337	08/02/85	2244	4.0	Good	
36	204	39.239	75.386	08/02/85	2308	5.0	Bad	Removed from dataset
37	32	39.251	75.358	08/02/85	2259	1.0	Good	
38	204	39.239	75.386	08/02/85	2332	3.0	Good	
39	205	39.283	75.337	08/02/85	2344	4.0	Good	
40	32	39.251	75.358	08/02/85	2359	5.0	Good	

Table 5.2 Tape 4 of 7, Delaware River and Bay CTD Profile Inventory (Cont.)
Casts Taken with the AML CTD-12 Portable CTD Profiler in 1985 Field Season

Cast No.	Station No.	Lat (°N)	Long (°W)	Date	Time (UTC)	Plot Depth (m)	Status	Explanation
41	204	39.239	75.386	08/02/85	0008	3.0	Good	
42	34	39.290	75.313	08/03/85	0031	5.0	Good	
43	205	39.283	75.337	08/03/85	0044	3.0	Good	
44	32	39.251	75.358	08/03/85	0059	5.0	Good	
45	204	39.239	75.386	08/03/85	0108	3.0	Good	
46	2	38.813	75.038	08/08/85	1539	18.0	Edit (Data Pt.)	First point removed
47	23	39.039	75.158	08/08/85	2031	9.0	Edit (Data Pt.)	First point removed
48	33	39.269	75.348	08/08/85	2241	15.0	Edit (Data Pt.)	Last point removed
49	151	39.505	75.920	08/08/85	1304	8.0	Good	
50	152	39.526	75.872	08/09/85	1350	12.0	Good	
51	154	39.561	75.570	08/09/85	1548	12.0	Good	
52	2	38.813	75.038	08/14/85	2132	18.0	Good	
53	51	39.880	75.173	08/15/85	1241	14.0	Edit (Data Pt.)	Last point removed
54	154	39.561	75.570	08/15/85	1711	12.0	Edit (Data Pt.)	First point removed
55	33	39.269	75.348	08/15/85	2030	15.0	Edit (Data Pt.)	Last point removed
56	23	39.039	75.158	08/15/85	2346	10.0	Edit (Data Pt.)	First point removed
57	206	39.248	74.500	08/17/85	1544	14.0	Edit (Data Pt.)	Last point removed
58	16	39.201	74.413	08/17/85	1621	17.0	Good	
59	207	39.152	74.304	08/17/85	1752	22.0	Good	
60	208	39.077	74.167	08/17/85	1837	30.0	Edit (Data Pt.)	First point removed
61	17	39.051	74.072	08/17/85	1924	30.0	Edit (Cast Depth)	Depth changed from 10' to 99'
62	209	39.002	73.998	08/17/85	2038	30.0	Edit (Cast Depth)	Depth changed from 12' to 99'
63	210	38.982	73.892	08/17/85	2116	30.0	Edit (Cast Depth)	Depth changed from 11' to 99'
64	211	38.925	73.797	08/17/85	2155	30.0	Edit (Cast Depth)	Depth changed from 13' to 99'

Table 5.3 Tape 5 of 7, Delaware River and Bay CTD Profile Inventory
Casts Taken with the AML CTD-12 Portable CTD Profiler in 1985 Field Season

Cast No.	Station No.	Lat (°N)	Long (°W)	Date	Time (UTC)	Plot Depth (m)	Status	Explanation
1	24	39.067	75.070	09/18/85	1917	5.0	Good	
2	22	39.016	75.251	09/18/85	2005	9.0	Good	
3	32	39.251	75.358	09/22/85	1751	6.0	Edit (Time)	Stations 3 & 4 have identical time and locations
4	32	39.251	75.358	09/22/85	1751	6.0	Edit (Time)	
5	34	39.290	75.313	09/22/85	1821	6.0	Edit (Time)	Stations 5 & 6 have identical time and locations
6	34	39.290	75.313	09/22/85	1821	6.0	Edit (Time)	
7	205	39.283	75.337	09/22/85	1830	4.0	Good	
8	32	39.251	75.358	09/22/85	1840	6.0	Good	
9	204	39.239	75.386	09/22/85	1848	3.0	Good	
10	34	39.290	75.313	09/22/85	1921	6.0	Good	
11	205	39.283	75.337	09/22/85	1930	3.0	Edit (Time)	Stations 11 & 12 have identical time and locations
12	32	39.251	75.358	09/22/85	1930	6.0	Edit (Time)	
13	204	39.239	75.386	09/22/85	1950	3.0	Good	
14	34	39.290	75.313	09/22/85	2021	6.0	Good	
15	205	39.283	75.337	09/22/85	2030	3.0	Good	
16	204	39.239	75.386	09/22/85	2048	2.0	Bad	Removed from dataset
17	34	39.290	75.313	09/22/85	2120	6.0	Edit (Data Pt.)	One point removed
18	205	39.283	75.337	09/22/85	2130	4.0	Good	
19	32	39.251	75.358	09/22/85	2153	6.0	Good	
20	204	39.239	75.386	09/22/85	2206	3.0	Good	
21	34	39.290	75.313	09/22/85	2224	6.0	Edit (Data Pt.)	Last point removed
22	205	39.283	75.337	09/22/85	2233	4.0	Good	
23	32	39.251	75.358	09/22/85	2247	6.0	Good	
24	204	39.239	75.386	09/22/85	2302	3.0	Good	
25	34	39.290	75.313	09/22/85	2324	5.0	Good	
26	205	39.283	75.337	09/22/85	2333	4.0	Good	
27	32	39.251	75.358	09/22/85	2343	5.0	Good	
28	204	39.239	75.386	09/22/85	2350	3.0	Good	
29	34	39.290	75.313	09/23/85	0013	6.0	Edit (Data Pt.)	Last point removed
30	205	39.283	75.337	09/23/85	0027	4.0	Good	
31	32	39.251	75.358	09/23/85	0049	5.0	Good	
32	201	38.889	74.860	03/21/85	1430	9.0	Good	
33	30	39.179	75.273	03/21/85	1535	12.0	Good	
34	27	39.130	75.183	03/21/85	1612	7.0	Edit (Data Pt.)	First point removed
35	59	38.983	75.128	03/21/85	1728	11.0	Good	
36	200	38.732	74.961	03/21/85	1801	16.0	Edit (Data Pt.)	Last point removed
37	3	38.859	75.024	03/21/85	1826	9.0	Good	
38	59	38.983	75.128	03/26/85	1731	11.0	Good	
39	59	38.983	75.128	03/28/85	2237	12.0	Good	
40	59	38.983	75.128	03/29/85	1608	12.0	Good	

Table 5.3 Tape 5 of 7, Delaware River and Bay CTD Profile Inventory (Cont.)
Casts Taken with the AML CTD-12 Portable CTD Profiler in 1985 Field Season

Cast No.	Station No.	Lat (°N)	Long (°W)	Date	Time (UTC)	Plot Depth (m)	Status	Explanation
41	24	39.067	75.070	04/03/85	1547	5.0	Good	
42	205	39.283	75.337	04/03/85	1558	3.0	Good	
43	205	39.283	75.337	04/03/85	1602	3.0	Good	
44	201	38.889	74.860	04/03/85	1613	9.0	Good	
45	32	39.251	75.358	04/03/85	1628	5.0	Good	
46	204	39.239	75.386	04/03/85	2009	3.0	Good	
47	32	39.251	75.358	04/03/85	2022	5.0	Good	
48	201	38.889	74.860	04/03/85	2035	9.0	Good	
49	203	38.916	74.951	04/03/85	2048	6.0	Good	
50	34	39.290	75.313	04/03/85	2059	6.0	Edit (Data Pt.)	First point removed
51	21	39.008	75.284	04/04/85	1424	6.0	Good	
52	22	39.016	75.251	04/04/85	1437	10.0	Good	
53	23	39.008	75.251	04/04/85	1448	11.0	Good	
54	24	39.067	75.070	04/04/85	1508	6.0	Good	
55	25	39.078	74.981	04/04/85	1528	5.0	Good	
56	25	39.078	74.981	04/04/85	1800	5.0	Edit (Data Pt.)	First point removed
57	24	39.067	75.070	04/04/85	1824	6.0	Good	
58	23	39.008	75.251	04/04/85	1846	11.0	Edit (Data Pt.)	Last point removed
59	22	39.016	75.251	04/04/85	1913	10.0	Good	
60	21	39.008	75.284	04/04/85	1925	5.0	Edit (Data Pt.)	First point removed

6. SUMMARY AND RECOMMENDATIONS

The DR&B Survey collected 755 CTD casts in 1984 and 1985. Three-hundred and twenty eight casts were immediately discarded since they had no time stamp and 10 other casts were removed for other reasons such as widely scattered data, a location error, duplication of the previous cast or not enough sampling points. Many of the sampling transects had incomplete data i.e. not all the results were included in the final dataset. Due to missing or conflicting data, the CTD dataset contains only time series results for Stations 2 and 47 in 1984 and Station 59 three times in 1985.

The DR&B Circulation Survey Report lists Station 19 as the only station that was sampled over time during the 1985 field season. There were no results of station 19 on any of the seven files of CTD data. Tapes 6 and 7 did have three time series samples done during April and May of 1985 at station 59 which was located approximately 2 nm southeast of station 19. There is no way of reconciling this discrepancy of station number so it is recommended to use the time series data at station 59 with the given location.

The AML CTD-12 Profiler was a portable, battery-operated device that was deployed on survey launches throughout the 1984-85 field season. The deployment logs for the CTD casts were not available for this analysis so it was not possible to reconcile discrepancies between the original files and the DR&B Circulation Survey report. Many of the CTD sampling stations were located near current meter stations. The CTD data should be cross checked with the current meter station data to further verify the AML CTD-12 profiles.

The data from the Delaware River and Bay Circulation Study will be used to set-up a nowcast/ forecast model test environment in the Delaware Bay and River to improve the prediction of storm effects on water levels.

Based on the experience gained from this project, the following are recommendations on how to recover CTD data from other historic NOS surveys:

1) Plot all CTD casts using a large format plotter.
2) Make a spreadsheet with the following information on each cast
    A. Cast number
    B. Station number
    C. Latitude
    D. Longitude
    E. Date
    F. Time
    G. Plot Depth
    H. Status of cast (G, B, or E)
    I. Explanation
3) Examine all casts and classify casts as good (G), bad (B) or need editing (E).
4) Search for old survey logs to help clarify problem casts. Many but not all survey logs are online at (http://noaa.imcwv.com/). You will need to create an account to log onto the site. The instructions are provided at the website.

5) Ask questions of people who conducted the survey—some people are still working for NOS twenty years later.
6) Plot all stations and look for consistent station locations (sometimes the locations are off by exactly one degree which can be classified as a transcription error).
7) Check station locations with the corresponding chart and look for consistency with charted depth and plot depth.
8) Sort all stations by time and check to make sure times don't overlap with other casts (Hint: look for duplicate dates and times on different stations).
9) Edit the casts that need modifications.
10) Create a new file with the edited data.

7. ACKNOWLEDGEMENTS

Dr. Frank Aikman, Chief of Marine Modeling & Analysis Programs for the Coast Survey Development Lab and Dr. Richard Schmalz conceived of the CTD Analysis Project as well as provided critical resources and leadership for the project. The project was sponsored as part of the NOAA Rotational Assignment Program.

8. REFERENCES

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APPENDIX A: CTD PROFILE SAMPLES

Appendix A contains graphic examples of common problems and modifications with the Grundy 9400 and AML CTD-12 instruments. The appendix contains raw data and edited files in Figures A.1 through A.10. Modifications include removal of a near-surface, middle or near-bottom point in the cast, adjusting the depth to incorporate more data, scattered data, and bad data which resulted in the cast being removed from the dataset.

EXAMPLE OF BAD CTD CAST

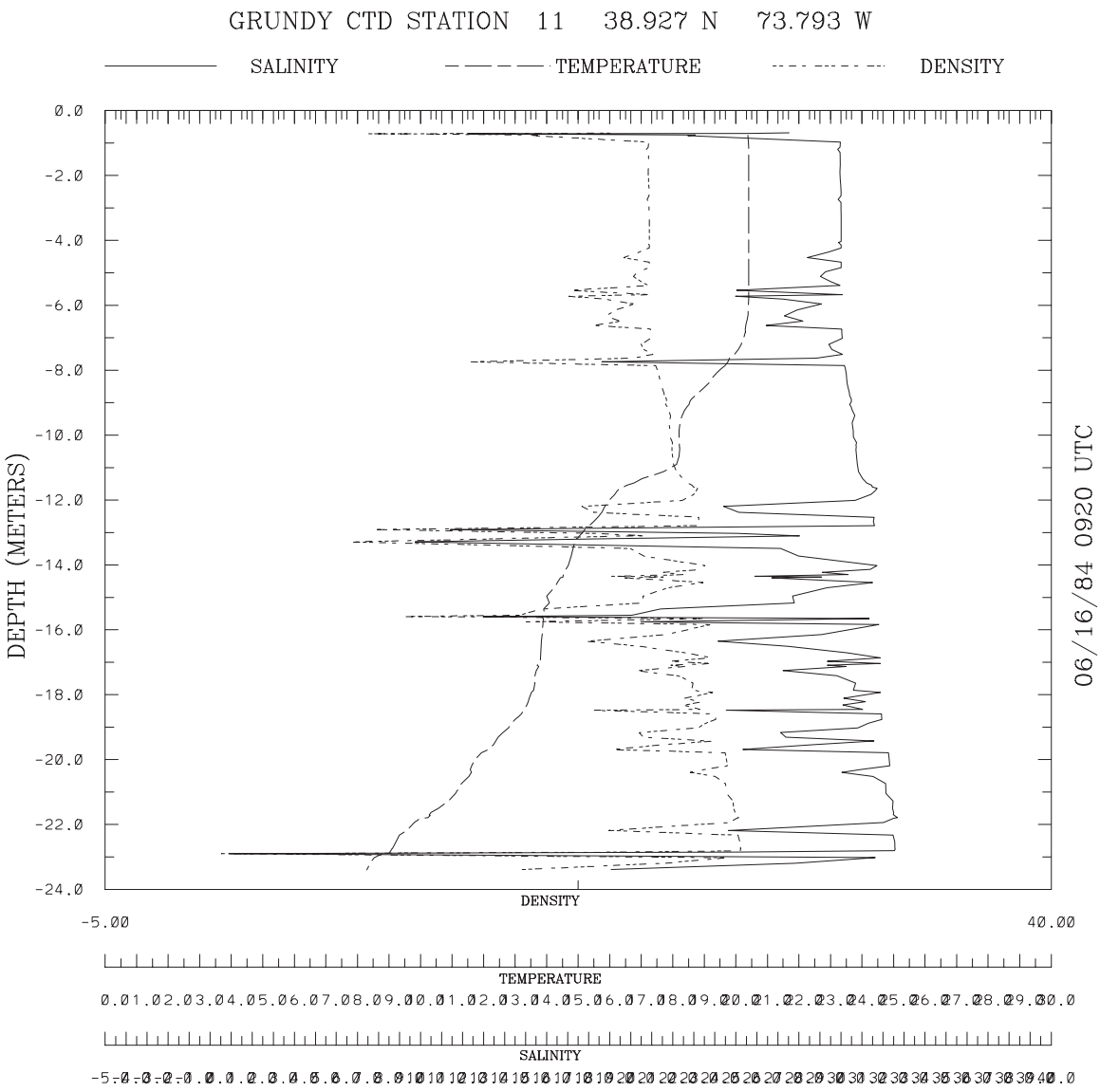

Figure A.1 Grundy 9400 CTD Profiler Cast with bad data.

EXAMPLE OF NOISY CTD DATA

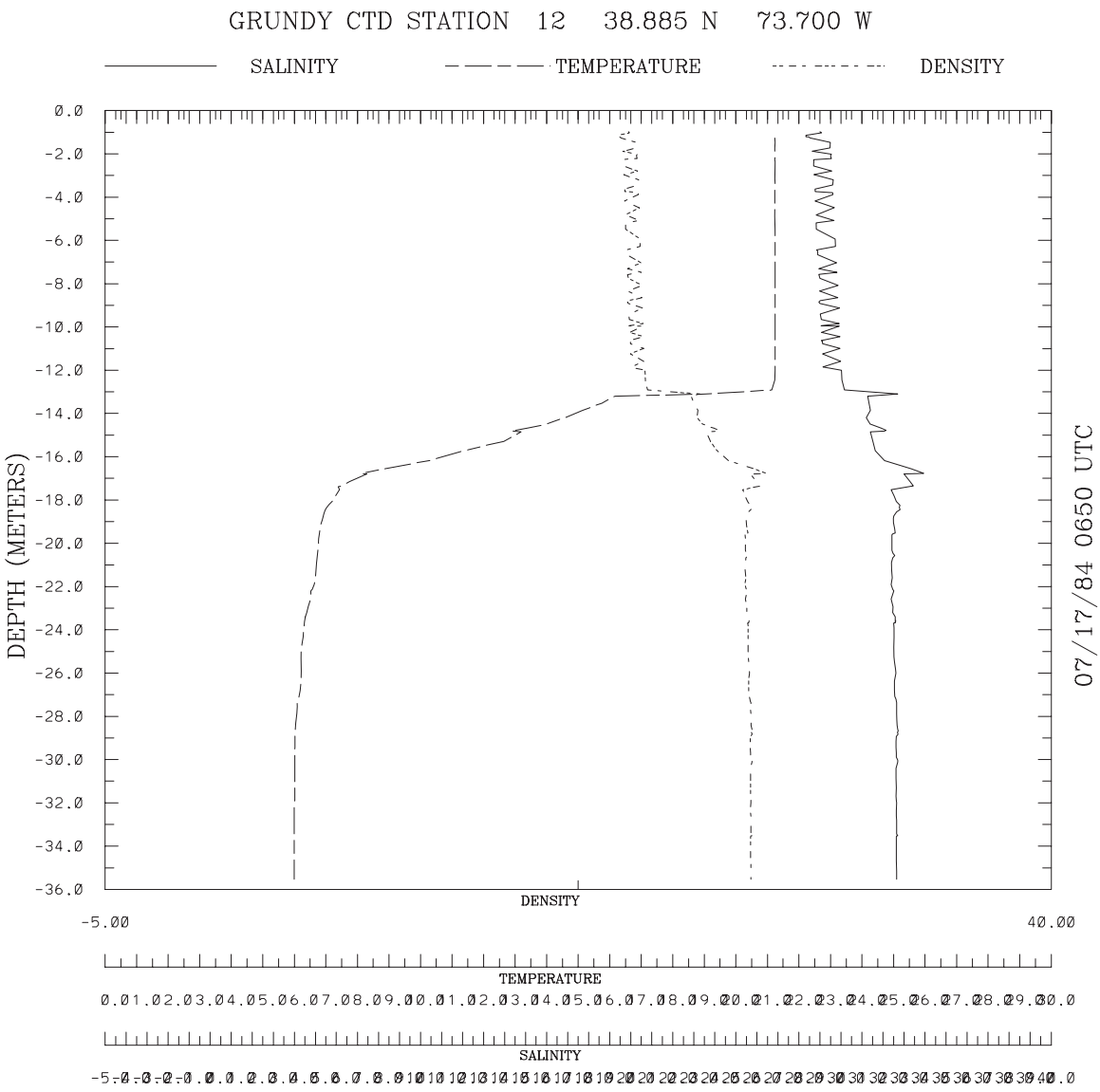

Figure A.2 Grundy 9400 CTD Profiler Cast with noisy but useable data.

EXAMPLE OF BAD INITIAL DATA POINT

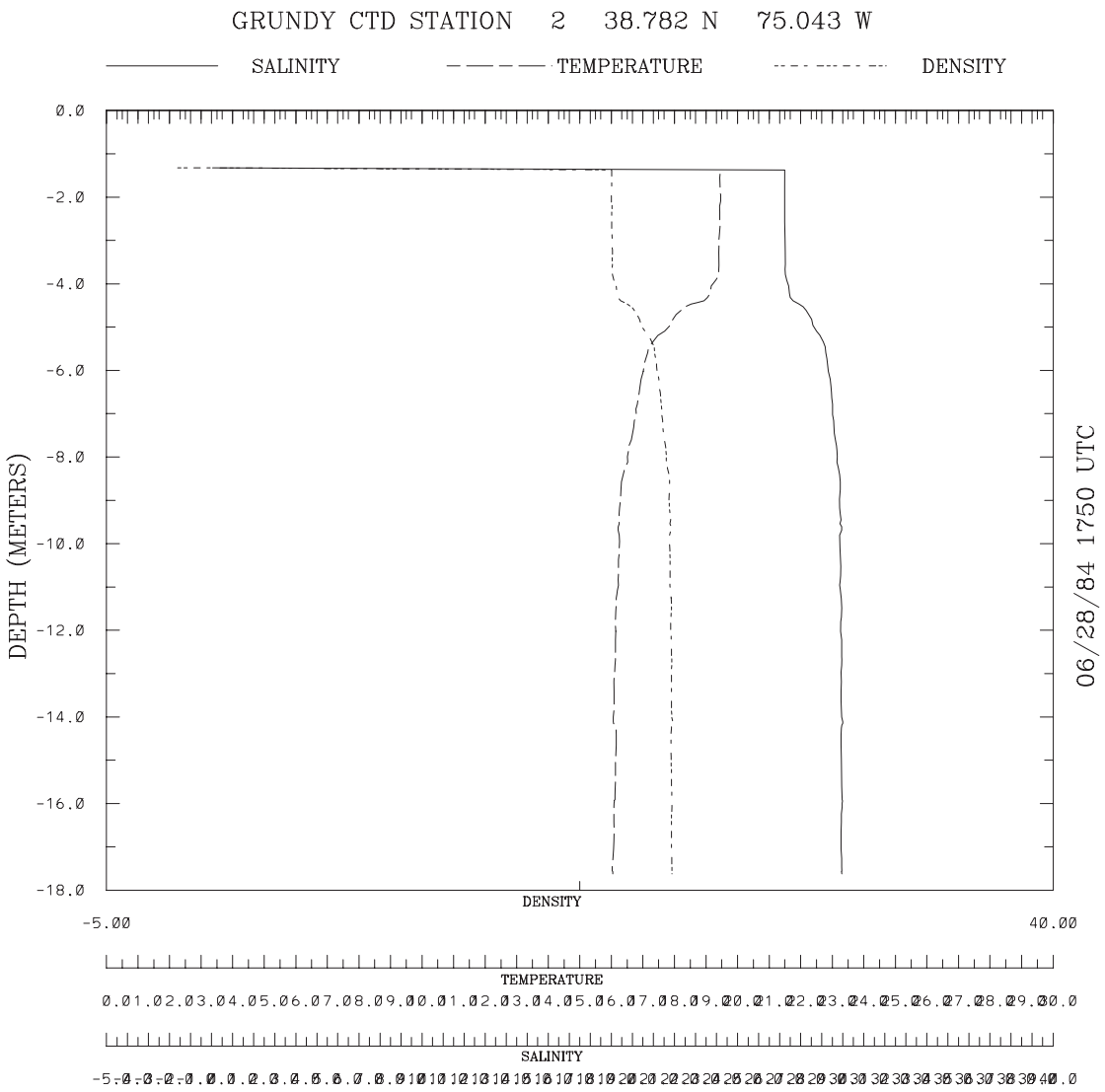

Figure A.3 Grundy 9400 CTD Profiler Cast with one bad initial point.

EXAMPLE OF BAD INITIAL DATA POINT REMOVED

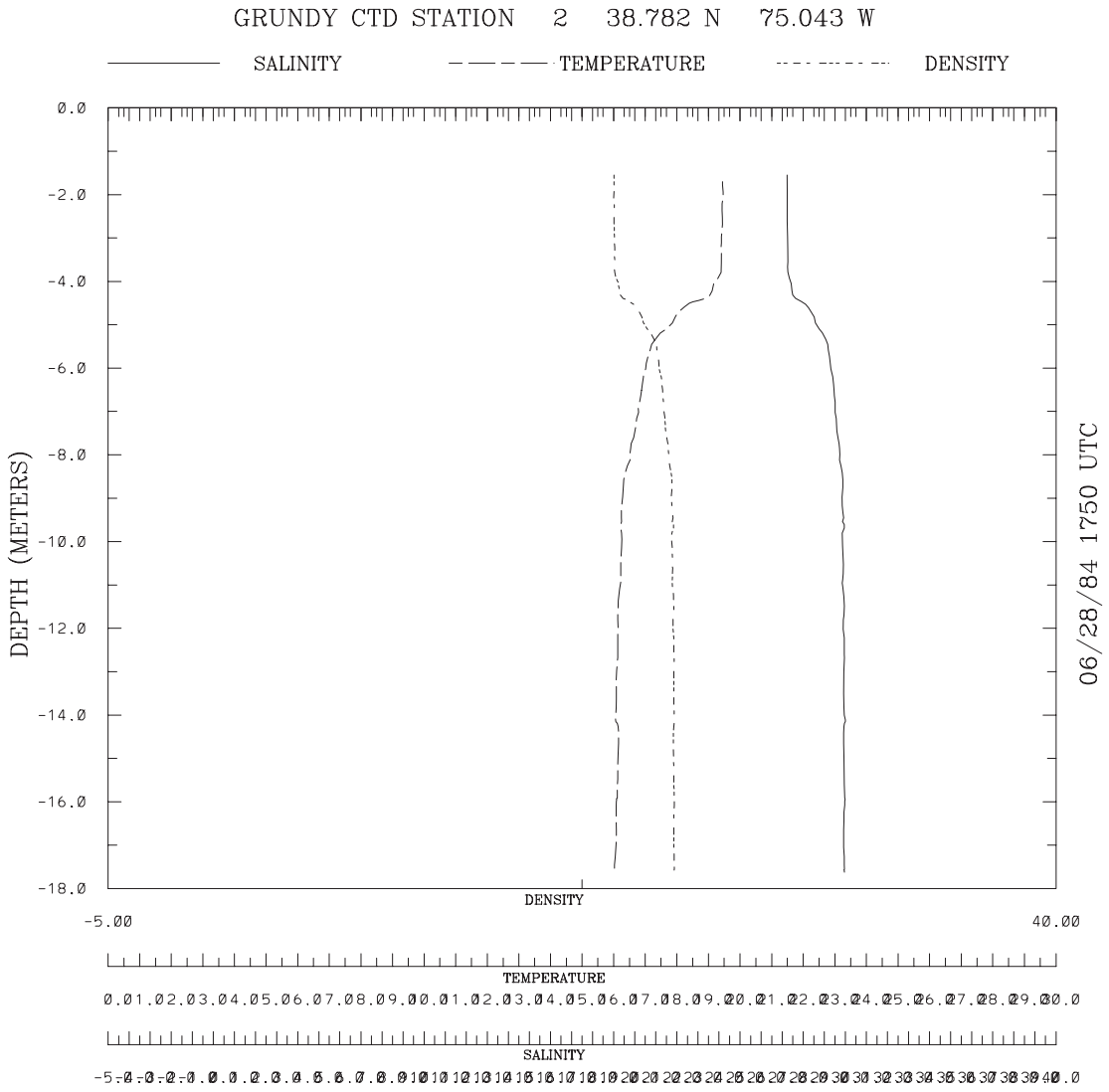

Figure A.4 Grundy 9400 CTD Profiler Cast with one bad initial point removed.

EXAMPLE OF BAD DATA POINT NEAR THE SURFACE OF THE CAST

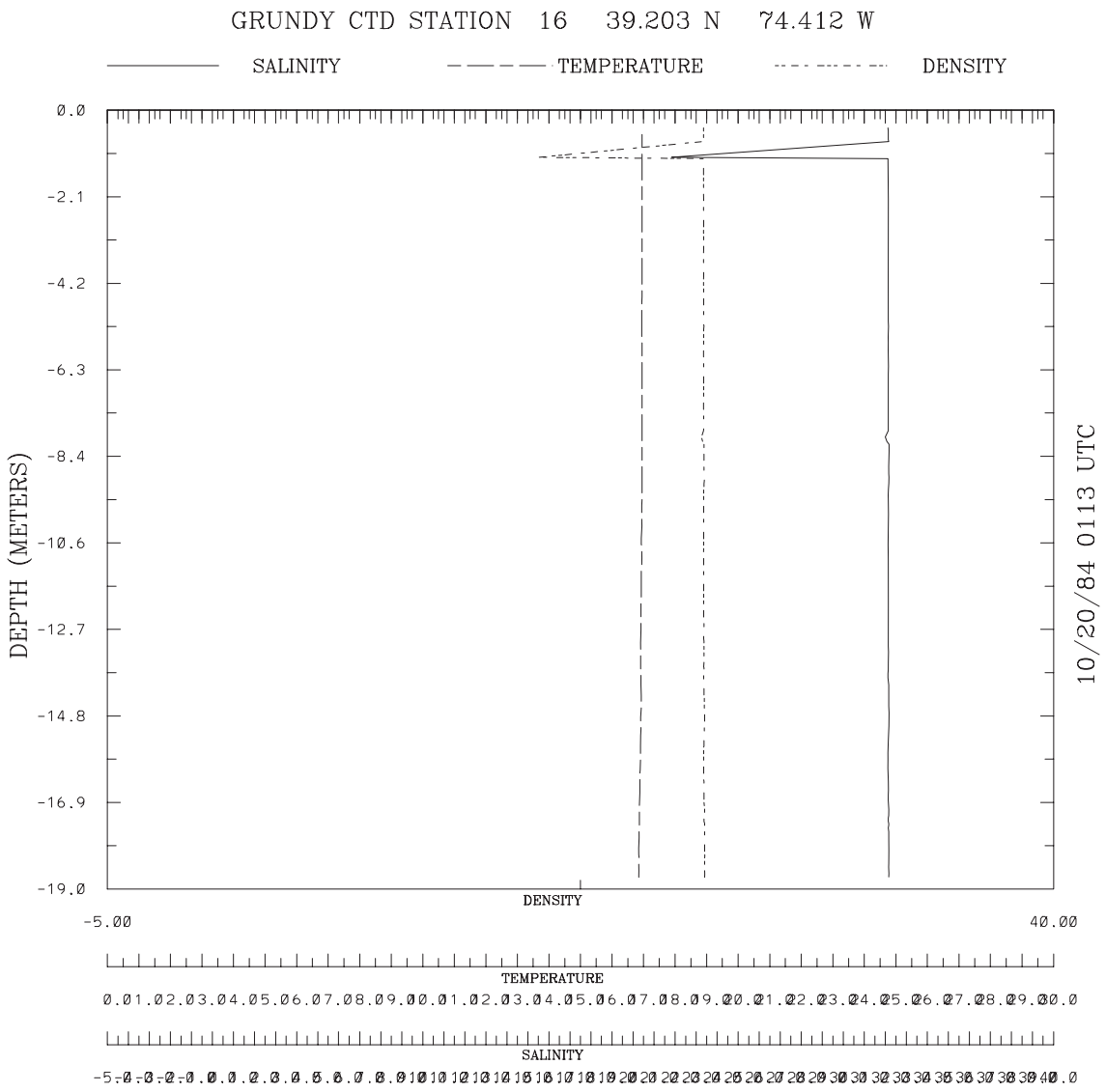

Figure A.5 Grundy 9400 CTD Profiler Cast with a bad point near the surface of the cast.

EXAMPLE OF BAD NEAR-SURFACE DATA POINT REMOVED

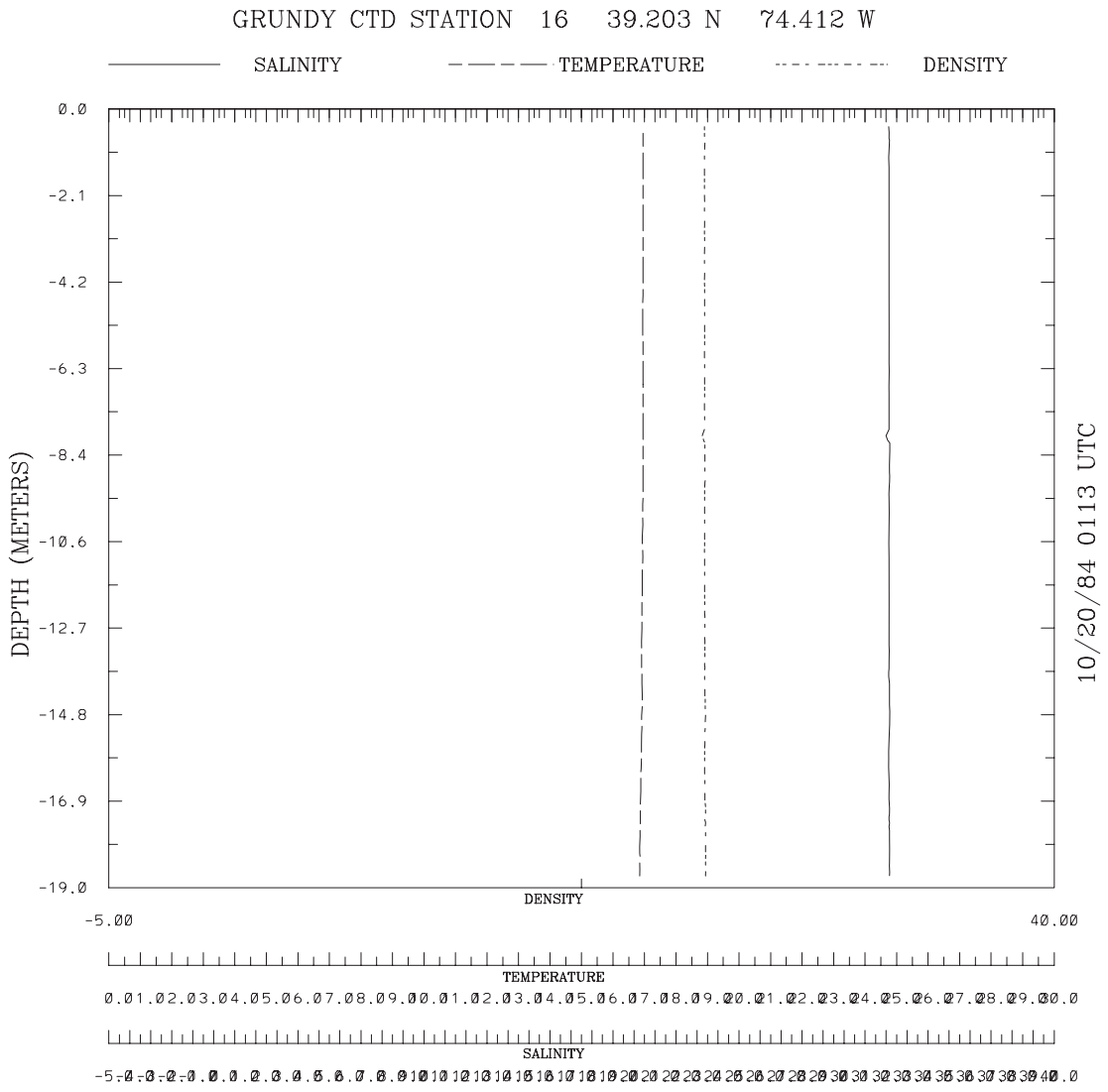

Figure A.6 Grundy 9400 CTD Profiler Cast with bad near-surface point removed.

EXAMPLE OF BAD NEAR-BOTTOM DATA POINT

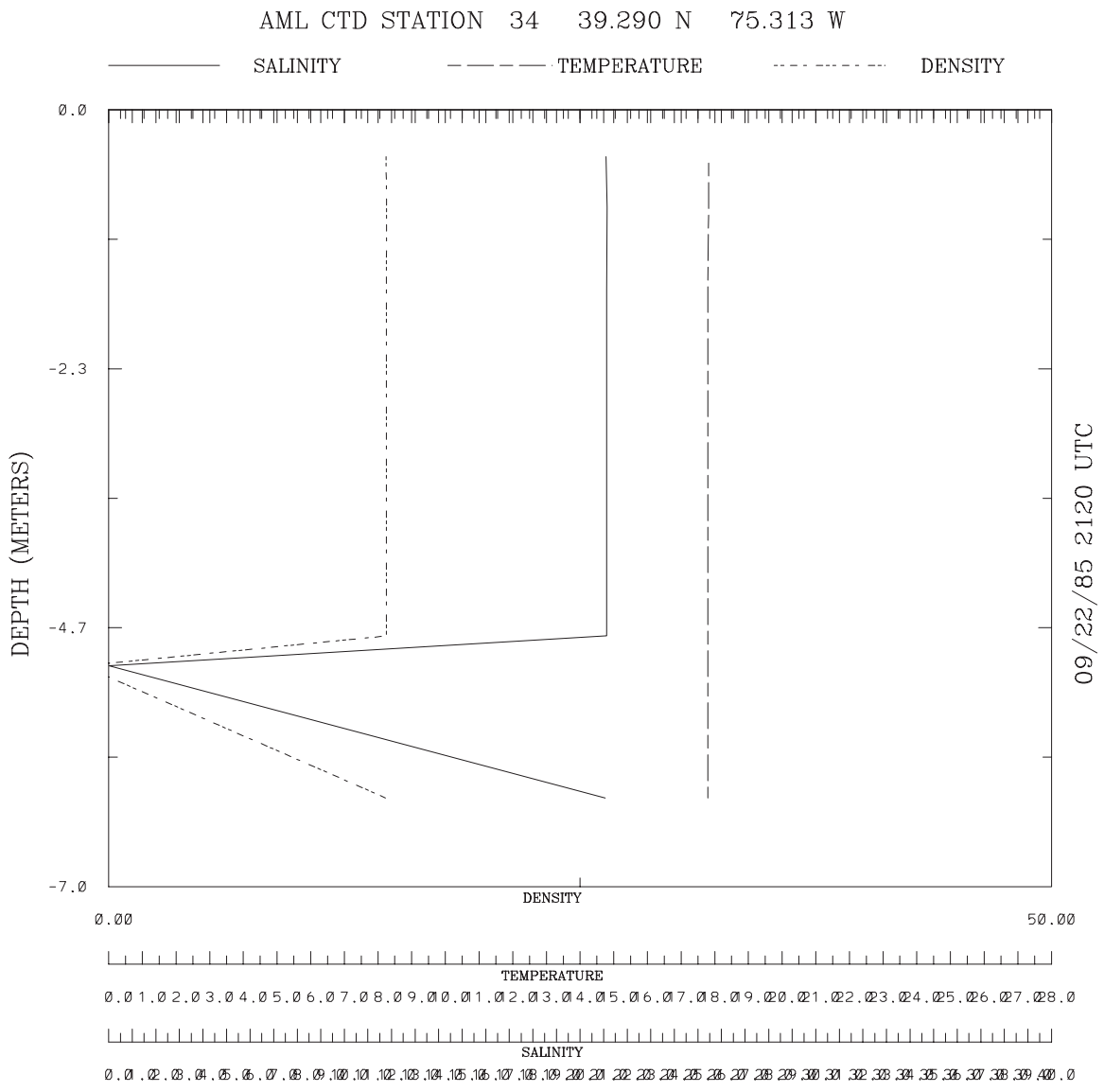

Figure A.7 AML CTD-12 Portable CTD Cast with bad near-bottom point.

EXAMPLE OF BAD NEAR-BOTTOM DATA POINT REMOVED

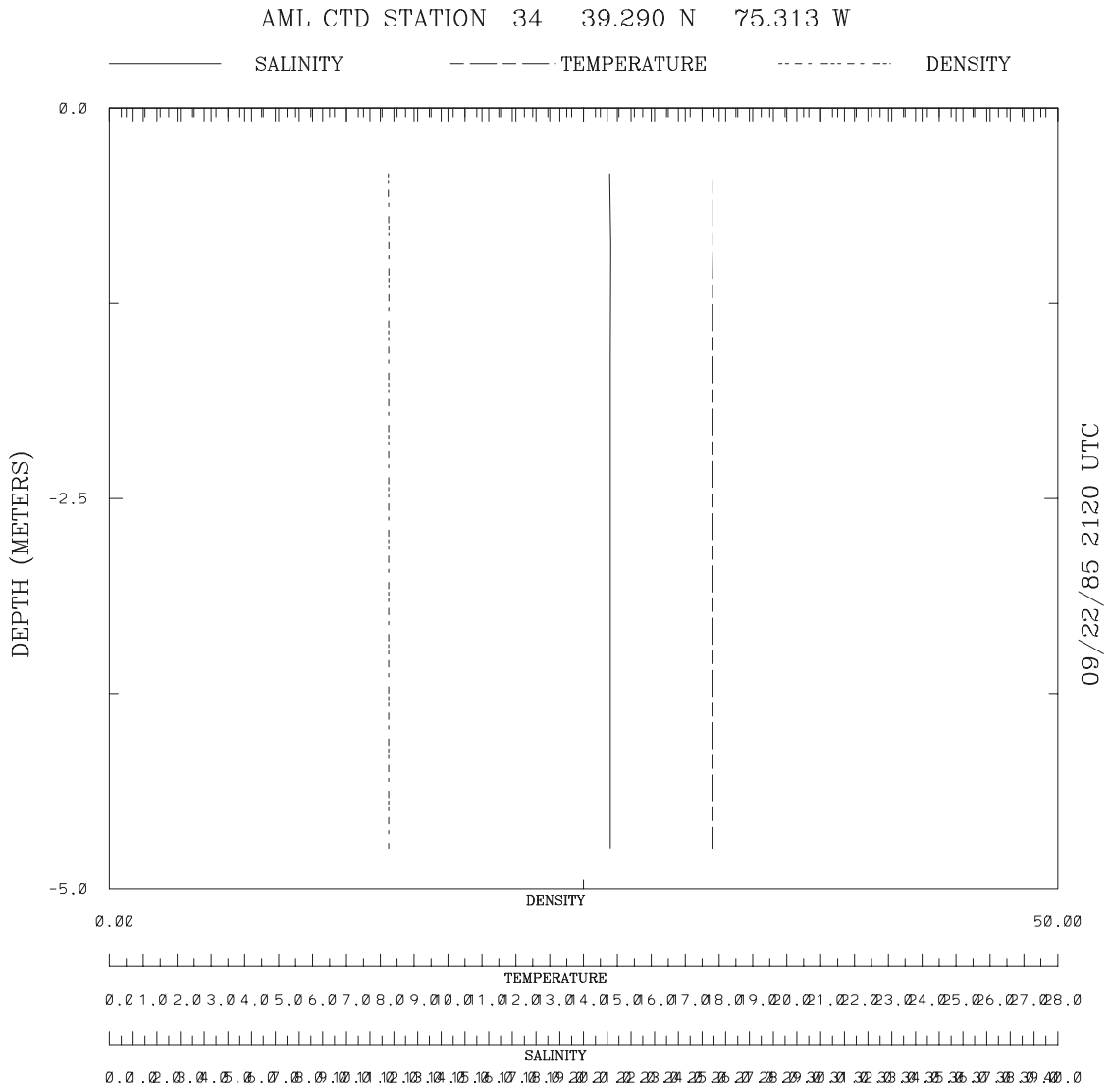

Figure A.8 AML CTD-12 Portable CTD Cast with bad near-bottom removed.

EXAMPLE OF BAD DEPTH

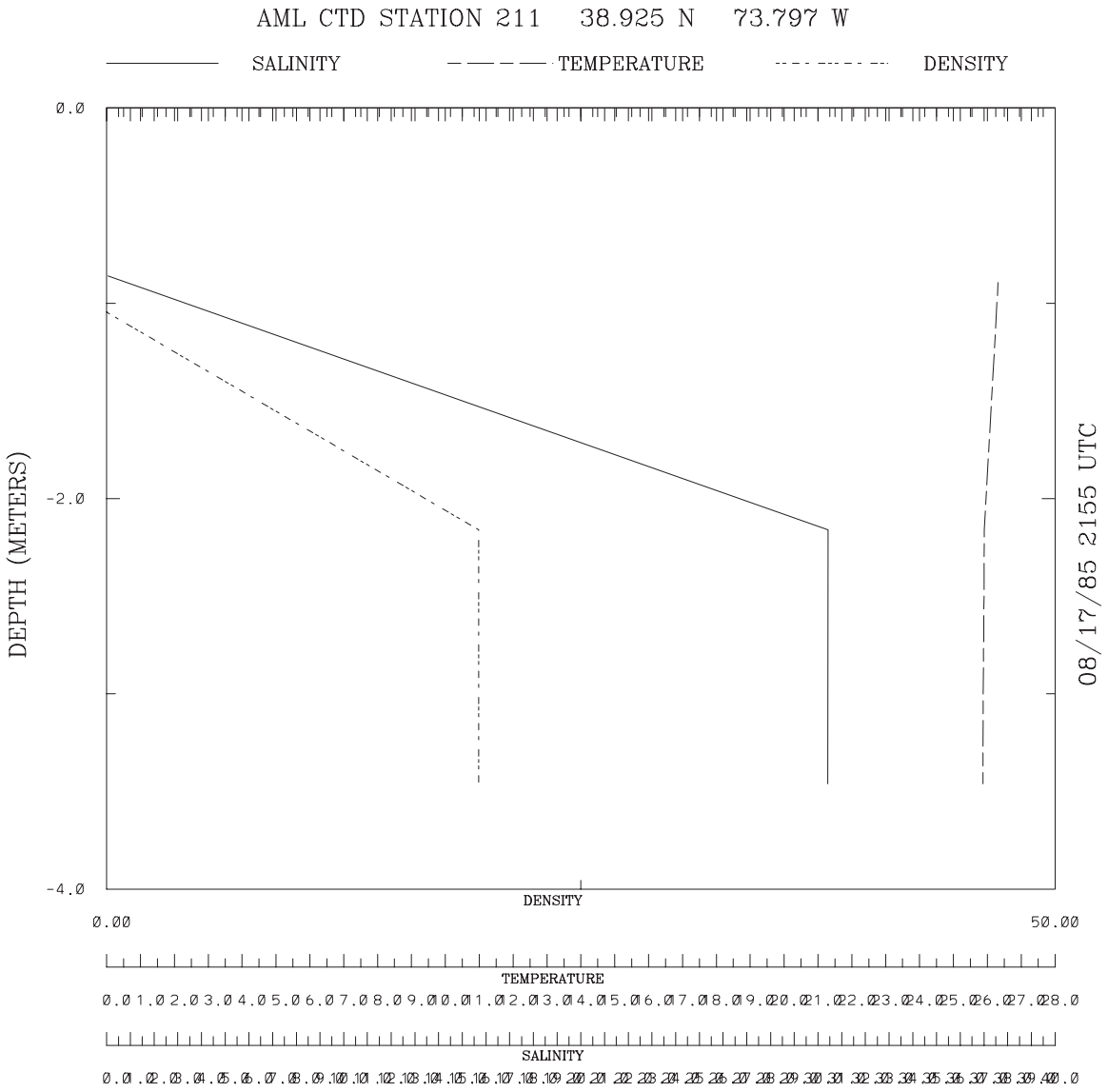

Figure A.9 AML CTD-12 Portable CTD Cast with an incorrect depth.

EXAMPLE OF BAD DEPTH CORRECTED

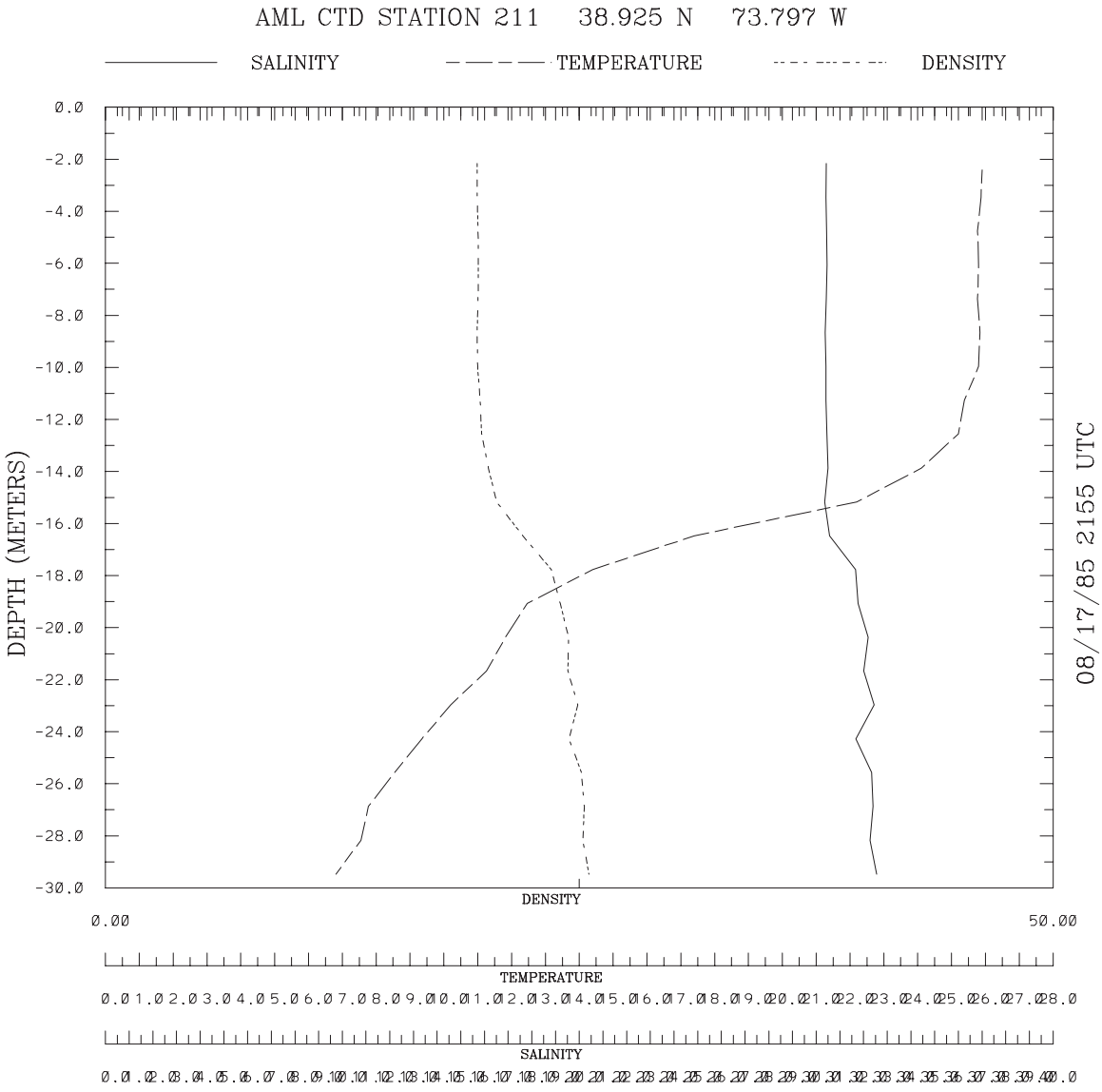

Figure A.10 AML CTD-12 Portable CTD Cast with depth corrected to 30 meters.